Frontispiece [Photo H T Reeves]

A picturesque spot of open forest country at Mt Zero, Victoria The quaint plants in the foreground are Grass Trees or Blackboys (Xanthorrhoea arborea).—

NATURE PROBLEMS

A Book of Nature Study for Young Australians

BY

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and A Turnidge
(except where otherwise indicated)

COMPANION VOLUME
A Handbook of Suggestions for Teachers By the same author

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TABLE OF CONTENTS

PAGE
Introduction 5

Unit 1.
Living Things 7

Unit 2.
Can you tell a Plant from an Animal? 17

Unit 3
How do Living Things protect themselves? 28

Unit 4
Why do Living Things need oxygen? . 67

Unit 5.
How do Plants and Animals get their food? .. . 89

Unit 6
How do Living Things make new Plants and Animals like themselves? 110

Unit 7.
What sort of plants does Australia produce 162

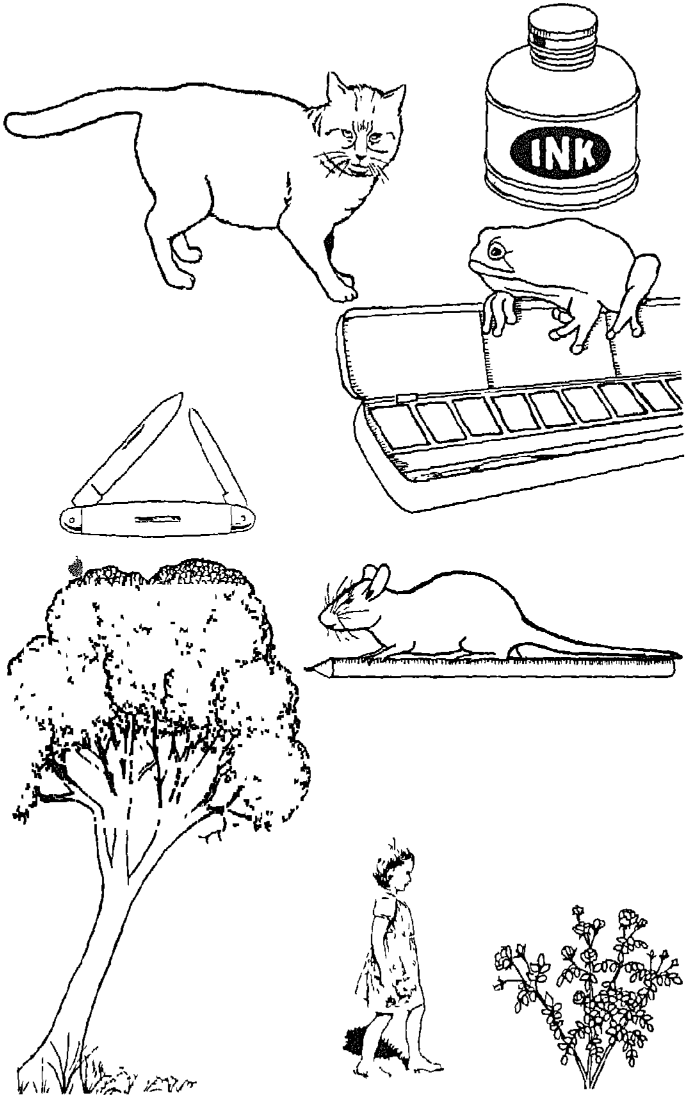
Unit 8.
What sort of animals does Australia produce? 186

INTRODUCTION

Nature is teeming with problems and man is an inquisitive animal A study of nature is, for that reason, full of interest to the average person, man or woman, boy or girl However, many of nature's problems are not easily solved None can be solved without patience and care But even the discovery of one of her simplest problems leaves a satisfied feeling to the seeker after truth.

It is with the idea of helping you in your search for the solution of a few of the simpler problems of nature that this little book has been written It does not pretend to be very far-reaching, nor does it pretend to give you very much information If the reader is inspired to follow some of the clues which nature holds out before his eyes and learns the very beginning of how to follow such clues, the writer will be satisfied Further suggestions for methods of investigation will be found in the handbook which has been compiled as a companion volume This companion volume has been written primarily for the use of teachers but should be useful to the novice embarking on explorations for himself in helping him with suggestions and selections.

One of the greatest difficulties in preparing work of this type is to find problems sufficiently simple for a starting ground. Nature has no simple or uninvolved problems It is true that there is no starting point in a study of nature Each tiny thread you unravel reveals itself as a multitude of even tinier threads, the destination of each linked up with that of all the others. You will never reach the point, I fear, at which you will have completely unravelled any one thread But I think you will get considerable satisfaction and great fun out of your attempts to probe some of these absorbing problems.



You and I and your friends are living things and so are frogs and toads and mice and trees and shrubs But ink, paint, penknives and pencils are non-living things

UNIT 1

Living Things

This book is about living things

What are living things?

That seems a very easy question

You know some types of living things very well indeed and you know some types of non-living things. You know, for example, that you and I and your friends are living things, and so are frogs and toads and mice and trees and shrubs And you know that ink and paint and pencils and penknives are non-living things.

But how do we distinguish between these things? Suppose someone asks you the difference between living and non-living things. How will you answer? That's not so easy At first you will probably be inclined to say that living things move and non-living things don't move. Then, if I remind you that plants are living things and don't seem to move and that a ball will move if you drop it on a hill, you will see that it is not so easy to answer. Let us go a little further If your house were on fire and you were inside you would quickly move out of it So would your cat or dog. Plants can't do this, although they are alive. Their power of movement is more restricted

A plant comes from a seed which, as it grows, **moves** up into the air and down into the soil. And your ball will only move if you give it a start

If you plant seeds where there is not enough light they will grow out towards the light. If you arrange a vase of **Nasturtiums** or **Marigolds** in the most artistic way you can you might spare yourself the trouble for you will find that your flowers have all turned their heads in the direction from which the light is coming

This sort of movement, which is brought about by some urge or stimulus outside the living body, is quite different from the outside force which causes your ball to roll The stimulus of likely danger makes you hurry out of a burning building The stimulus of light makes the plant turn towards it The stimulus of hunger may cause you to help yourself to a piece of cake and stimulus of water may cause the root of a plant to grow towards it But none of these things can cause your ball or a piece of stone to move from the place where it lies The sun may perish the rubber of your ball if you leave it out too long, the heat may crack the stone or the wind may wear it away but these lifeless things have no power to move of themselves like you have or like the plant has

This power to move by itself is called **spontaneous movement.**

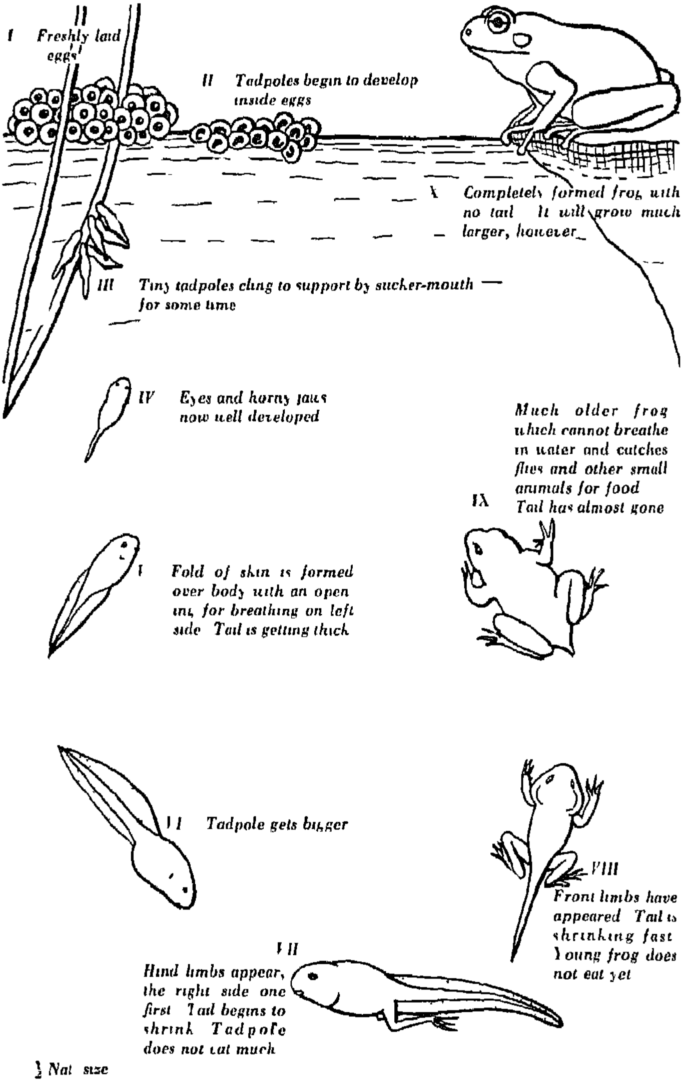
Living things possess the power of spontaneous movement. The child can run, skip, dance and indulge in many other activities The pea can grow, climb and make new parts by spontaneous activity This is a vital activity

Living things, then, differ from non-living in possessing the power of **SPONTANEOUS MOVEMENT.**

There are other things, too, which distinguish living from non-living things

You know that as the young plant pushes its way down into the soil and up into the air it grows or gets bigger Animals, too, grow and increase in size. Now this sort of increase in size is very different from the increase in size you get when you build a sand-pile on the beach Your sand-pile gets bigger and bigger and bigger, truly But it differs from the way in which your body gets bigger as you grow You can make your sand-pile smaller and smaller and smaller by taking away some of the sand you had piled up. But you can't do this to your own body or to a plant The new part which has been added to the plant or animal has now become part of that plant or animal and it can never be the same plant or animal that it was before.

Not only can living things make themselves bigger but they can repair the parts which wear out If you tear your coat you can repair it by putting a patch on it or by darning it The bootmaker can put more leather on the soles of your shoes when the old ones wear through. But neither the coat nor the shoes can repair themselves How does your body repair itself? You will remember at some time or other noticing the skin peeling off your nose or your arm or some other part of your body But that part of your body is now covered with new skin, made by your own body. Find some finger or toe or some other part of your body where you can remember having had a cut or a scratch. Now there is no trace of it left (unless it was a recent injury) because your body has repaired it. It is only when you injure yourself very badly that you need to have a doctor, and even then he usually helps the body to do its own repairing Inside your body, too, constant repair is going on


I Freshly laid eggs
II Tadpoles begin to develop inside eggs
III Tiny tadpoles cling to support by sucker-mouth for some time
IV Eyes and horny jaws now well developed
V Fold of skin is formed over body with an opening for breathing on left side Tail is getting thick
VI Tadpole gets bigger
VII Hind limbs appear, the right side one first Tail begins to shrink Tadpole does not eat much
VIII Front limbs have appeared Tail is shrinking fast Young frog does not eat yet
IX Much older frog which cannot breathe in water and catches flies and other small animals for food Tail has almost gone
X Completely formed frog with no tail It will grow much larger, however
½ Nat size

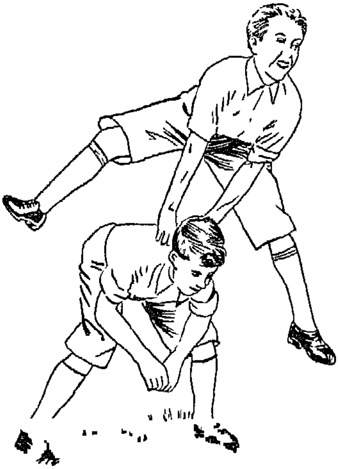
Living things grow They get bigger and bigger until they are full size or mature This is another vital activity

All plants and animals are able to repair themselves No individual parts last very long because they are constantly being worn out and replaced. Mostly this is not very noticeable For instance your skin is peeling off all the time in little pieces so that you are not aware of it. It is only when you allow yourself to get too burned in the hot sun that you notice your skin wearing away in big flakes. Because your body is not ready for it the skin underneath the flaked-off parts is very tender and may be very sore. But if you had let it come off more slowly it would not have been tender underneath as the top skin peeled off in tiny flakes. Many lizards and snakes shed the whole of their skin at one time. The new skin is very soft and not a very good protection until it hardens, so such animals usually go into hiding for a short time immediately after this skin shedding

There is another sort of growth that we should mention here, too. If you have ever visited limestone caves like those at Jenolan you will have seen the stalactites and stalagmites formed inside the caves, the former hanging from the roof and the latter growing up from the floor These grow bigger and bigger as the water, which contains lime, drips down on to them The water evaporates and leaves the lime particles behind So the stalactites and stalagmites seem to grow

Crystals, too, seem to grow. Have you ever made sugar candy? You can do it this way. Boil a little water and keep on adding sugar to it until no more will dissolve. That means that there will be some of the small crystals or grains of sugar left in the water You need to stir carefully all the time, otherwise the sugar will stick to the bottom of the saucepan. When you are satisfied that no more sugar will dissolve take the sugar solution (this is what we call sugar dissolved in water) off the gas. Now tie some pieces of fine string on to a stick and rest the stick across the vessel containing the sugar solution so that the strings dip into it After some hours you will notice that little lumps or crystals of sugar are beginning to grow along the string They are coming out of the solution.

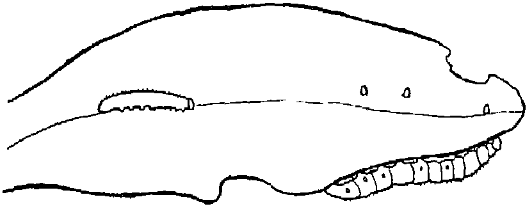
But this sort of growth, as it is sometimes called, is very different from the growth of living things. Limestone pillars can form from the limestone in water and sugar crystals can form from the sugar in water But when you grow, what you eat becomes part of you It is not just sugar in water becoming sugar out of water. It is milk or potato becoming human muscle or fat or hair or skin Or, if a cat drinks the milk, this milk is changed into new pads or fur or some other part of the animal



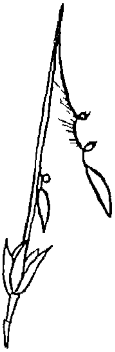
Living things need oxygen to help supply energy This is another vital activity

Living things, then, possess the **POWER OF GROWTH** which non-living things do not.

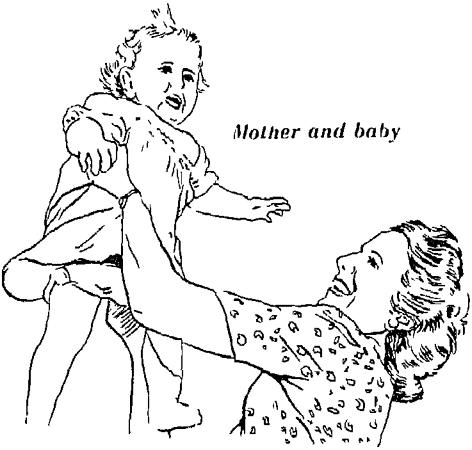
In order to grow, living things need **energy.** When you want to change food from one form to another



Caterpillar and eggs of the cabbage white butterfly



Geranium fruit



Mother and baby

Living things reproduce The butterfly produces eggs which develop into caterpillars and these later become butterflies The plant produces seed which may grow into new plants, and the human mother may produce babies which will become grown men or women This is another vital activity you cook it by means of heat. This heat is the energy which effects the change. When fruits are ripening on a plant they change very much, as you know by the difference in flavour of a ripe and an unripe fruit In this case the sun supplies the energy When bodies are growing they use the **oxygen** of the air to supply this energy. This is a little difficult to understand just yet But you do know that when you are exercising a good deal or eating your meal very rapidly (which you should not do, of course) you find it necessary to take deep breaths of air. This is because the air you are breathing contains the oxygen you need to supply your energy Other animals need oxygen for energy, too So do plants. Plants don't seem to require it as animals do, but later on we can show by experiment that plants do need oxygen to supply energy too You can see from what we have said that living things not only require energy for growth but they also require it for carrying out their ordinary programme of living You need it for moving, for eating, for thinking.

Living things use **OXYGEN TO HELP SUPPLY ENERGY** for helping them to carry on their life.

Finally, living things do something of which you are all aware and which non-living things cannot do They can reproduce or make new living things like themselves. Plants produce seeds which grow into plants like themselves Some animals, like butterflies and many lizards, produce eggs which grow into young like themselves And some animals, like humans and horses and cats, produce live young which grow into animals like themselves

It does not surprise you very much to hear that the cat has a batch of kittens or that the hen has hatched chickens from her eggs. A group of seedlings at the base of an old plant may interest you but you will have seen such a thing many times before A swarm of tiny caterpillars just near a group of empty white shells will suggest that they have not long crawled out of their eggs. But you would be bewildered if, one morning, you walked out to find a wee bath beside your big one or a miniature porridge plate beside your ordinary one! And you have certainly never seen a motor car drop a batch of eggs!

No non-living thing can do this.

Living things **REPRODUCE** other living things like themselves

So now if you want to know whether a thing is living or non-living ask yourself these questions about it.

Can it move without being helped?
Does it grow?
Does it need oxygen?
Can it reproduce?

Don't forget, of course, that living things cannot necessarily do all these things all the time. A young human baby, for instance, cannot move very far without being helped. But you know it will be able to do so later Very young animals cannot reproduce but you know that they will be able to do so when they are mature Grown-up people don't get bigger as a rule. But you know that they have grown

Now, out of this list of things pick out the living things and write down which of the four things listed above each can do.

Pig, chicken, butter, coal, bean plant, wood, caterpillar, frog, moth, hen, bean seed, paper, potato, egg, apple, grass, newspaper, penny.

CAN YOU TELL A PLANT FROM AN ANIMAL?

(See coloured plate opposite)

On the page opposite is a well-grown plant. The soil has been cut away so that you can see the way the roots penetrate the soil

Think of all the things that plant has done since it first began to grow from a tiny seed

It put those fine, white roots down into the soil. As it goes on growing the roots will grow longer and will travel further. It put that shoot up into the air. As it goes on growing more leaves will be formed and the stem will grow stronger and longer

YOU CANNOT SAY A PLANT IS UNABLE TO MOVE CAN YOU?

Turn to page 18 and look at the animals shown there—a sea anemone, a coral and a sponge They don't look much like animals do they? They don't move very far But they are animals Sponges and corals remain attached although they may grow

YOU CANNOT SAY AN ANIMAL CAN ALWAYS MOVE FROM PLACE TO PLACE CAN YOU?

But there is one thing you are sure to remember about the green plant It has green leaves which only develop properly in the light These leaves are used by the plant for making its food. How it does this you will learn later on

A PLANT MAKES ITS OWN FOOD

But animals do not do this They either eat other animals or they eat plants. If they eat other animals you may depend upon it these animals eat plants or, if they do not, the animals they feed on eat plants

ANIMALS ARE DIRECTLY DEPENDENT ON PLANTS FOR THEIR FOOD

Do you know all the things this living plant can do?

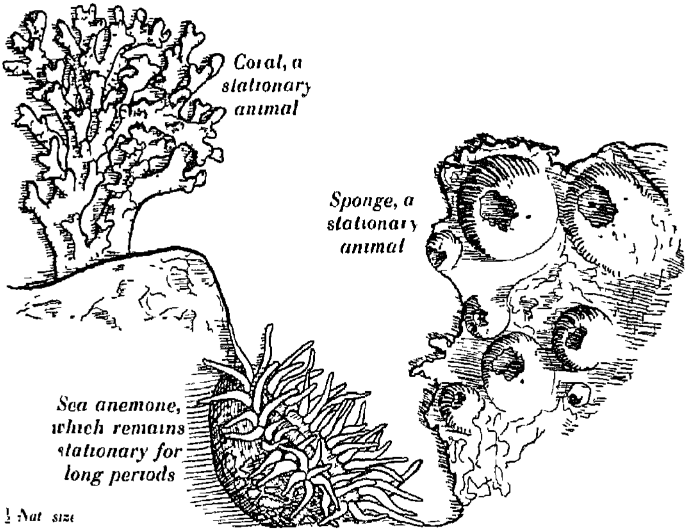
UNIT 2

Can you tell a Plant from an Animal?

That seems an easy question At first you would say, "Certainly I can I'm an animal, you're an animal, my cat, my dog, a kookaburra, butterflies, moths, frogs, snakes, are all animals And trees and flowering shrubs and annual plants like poppies and nemesias, and ferns and mosses are plants." Yes, that's all right but, at the same time, there are some plants and animals that it is really difficult to decide about. What about sea anemones and sponges? And what about corals? If you had a microscope I could show you tiny little swimming plants that move actively in water

If you have ever kept a glass aquarium you have probably seen the water in it turn green quite suddenly One day it is quite clear The next day, or maybe later in the same day, it has little green patches in it Later again these green patches spread until the whole of the water is a bright green colour This colouring is due to the growth of tiny, green, water plants They have been in the water all the time but you have not seen them because there were only a very few of them Then, quite suddenly, the conditions for their growth get much better and they begin to grow and move about all through the water at a very rapid rate

Then, of course, you have all watched flower buds opening out into flowers, and leaf and branch buds opening out without any outside help You have seen how very rapidly a tiny plant can grow into a big one, moving up into the air and down into the soil Many plants grow much more rapidly than you do, even though most of them don't move from place to place.


Coral, a stationary animal
Sponge, a stationary animal
Sea anemone, which remains stationary for long periods
½ Nat size

These animals — sea anemones, corals and sponges — are not apparently active yet they are true animals Sea anemones may stay fixed for very long periods and corals and sponges never move from their position on the rocks once they have settled there

Well, you should be able to see from this that it is necessary to have some very marked way of distinguishing between plants and animals It is of no use having some differences which will enable us to distinguish between some plants and animals but not others. So it is no use saying, "Cats and dogs and humans move about rapidly but trees are always rooted in one place and so this distinguishes animals from plants," because corals and sponges don't move about from place to place and those tiny water plants I have been telling you about do

There is, however, one very constant difference between plants and animals That is in the way they get their food What do animals live on? Take some examples. Kangaroos, koalas (pronounce kō'la), sheep live on plant food. Dingoes live on flesh which, in turn, lives on plant food. Even if dingoes ate flesh-eating animals these same flesh-eating animals (such as native cats) feed on plant-eating animals (such as rabbits) So that it comes to the same thing in the long run

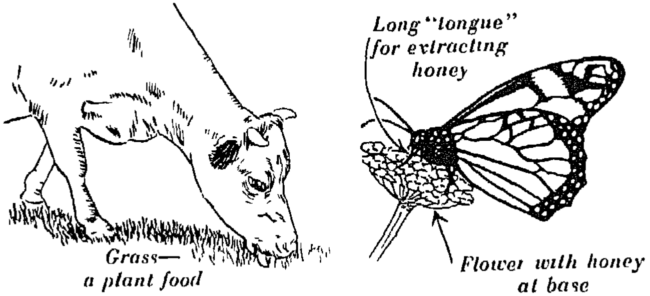
Think of some of the animals you know and consider their food Your pet cat feeds, in the main, on rabbit, which is a plant-feeder, and beef, which comes from the plant-eating cow. If the grass were not there to feed the cow, the cow would die and the cat would have no food. Or, alternately, if you foolishly allow your cat to go "wild" in the bush it will live on animals, such as small birds, which it catches These birds either live on honey, fruits and seeds which are plant products, or insects such as caterpillars, which themselves eat plants in order to live. So, whether the animal you are thinking about is **herbivorous** (grass-eating) or **carnivorous** (flesh-eating) it is finally dependent on plants for its food.

ANIMALS ARE DEPENDENT ON PLANTS FOR THEIR FOOD.

But what about plants? How do they get their food? They don't eat other plants or animals You can grow a healthy bean plant from a seed by giving it moisture, soil or a little mineral salt mixture and exposing it to air and light Plants get their food from the soil in which their roots are embedded and the air which surrounds the shoot. In order to use this raw food plants have to be provided with a green colouring matter called **chlorophyll**, of which you will hear more later So we can say, generally,

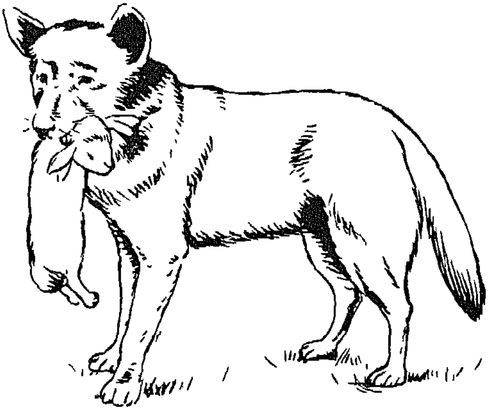
ANIMALS ARE DEPENDENT ON PLANTS FOR THEIR FOOD. PLANTS ARE DEPENDENT ON LIGHT AND MOISTURE FOR THEIR FOOD.

Now this explains something else for you. Since animals live on other animals or on plants they have to pursue their food. If they are **carnivorous,** living on other animals, they often have to be very fleet of foot If they live on plants they do not need to be fleet of foot, in order to catch their food, but they do need to be able to move from place to place to get enough food They do need to be fleet of foot in order to avoid being eaten by pursuing, flesh-eating animals or else to have some other means of protection



Animals are dependent on plants for food Some animals, like the cow, feed directly on plant food Butterflies eat honey, a plant product

This does not explain such peculiar animals as corals, sea anemones and sponges. These animals do not pursue their food. Indeed, they sit down and wait for it to be brought to them. The moving water obligingly does this in the form of minute plant and animal life in the water, which passes into the body of these animals and is engulfed

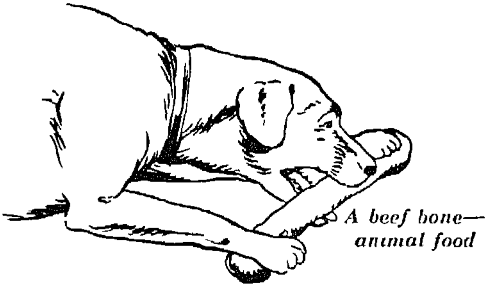


The dingo is a flesh-eating animal This dingo is about to eat a rabbit The rabbit is a vegetable feeder, so the dingo is indirectly dependent on plant food

So you can see that, on the whole, animals **need** to move about to get their food

But plants need only a place in the sun They would do no better if they moved from place to place

There are one or two peculiar plants which need your attention because they seem to be different from



The dog is also a flesh-eating animal The cow which supplied the bone is herbivorous (grass eating) other plants First, there are plants like the Sundew, the Pitcher Plant and others which seem to be **carnivorous** like animals, catching small animals and consuming them. It is true that they do this, but, at the same time, they make their food in the same way as other plants If you examine the leaves of the Sundew you will see that they contain the green colouring matter, chlorophyll, and so they are able to make their own food like all ordinary plants They use the green colouring matter, **chlorophyll,** the light of the sun and moisture and air The trapped, small animals are a supplementary diet only, which gives them more nitrogen and so enables them to live in places where nitrogen is not very easily obtained But the leaves are covered, too, with long reddish hairs which often have drops of moisture hanging from the swollen tips As these drops of moisture glisten in the sunlight they look very attractive To small, flying creatures they no doubt look like inviting flowers with honey in them Flying down to sample the feast, a small creature is soon caught in the sticky hairs which bend over and hold him prisoner (this is another example of plant movement) If the creature is fairly large or struggles very hard the leaf will bend right over and hold him down firmly Then the sticky liquid which first attracted the creature to his doom, is poured over him and digests him just as the digestive juices in your body act on the foods you eat When this nitrogen-containing morsel has been drained of all its food the hairs bend back again to their original position and the empty shell or carcase of the trapped creature will soon be knocked off by the wind. So the leaf is now ready for another victim

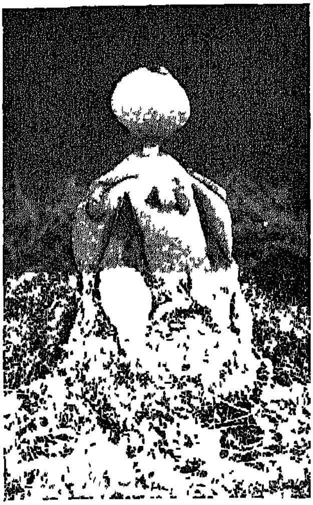
The pitcher plant, another one of these plants which supplements its nitrogen supply in this way, has the end of the leaf converted into a deep pitcher into which unwary creatures often fly to their doom The indigestible solid remains lie in the base of the pitcher and, in an old leaf, some hundreds of these may be seen

Nitrogen is a gas which is present in air and which is needed by all living things. At the same time it is a very inactive substance and can only be used by living things when it is combined with some other substance or substances We get our nitrogen in the proteins which we eat in such foods as lean meat, eggs and cheese Plants get theirs in the form of dissolved mineral salts in the soil That is why gardeners so often use fertilisers like ammonium sulphate and Chili saltpetre, which are rich sources of nitrogen. Some soils, particularly some kinds of boggy soils, do not have much dissolved nitrogen-containing substances, and most plants cannot live successfully in them Plants which have learned to supplement their diet by trapping small creatures and getting enough nitrogen this way can live successfully in soils which are very poor in nitrogen

½ Nat size

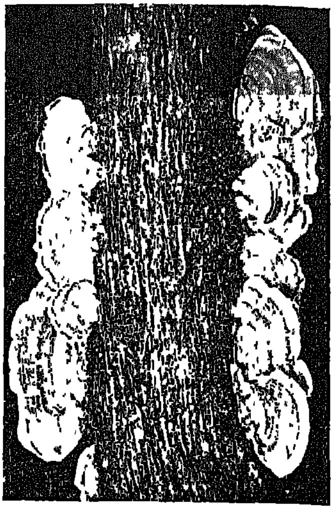
The Sundew (Drosera) supplements its diet by using the nitrogen out of the bodies of small animals

Another group of plants which is very puzzling is the group known as **fungi.** To this group the mushrooms and toadstools belong You will not doubt that they are plants, and yet they have no **chlorophyll** or green colouring matter and they live on living plants (such as tree stems), or on rotting plant-life, like dead tree stumps or manure in the ground. They do not make their own food like other plants. All I can tell you about them just now is that they are **degenerate plants** which, at one stage of their ancestral history,



[Photo H T Reeves]

Mushrooms, toadstools and other fungi do not have any green colouring matter They live on the products of other plants and animals
This earth star (geaster) lives on plant and animal products in the soil



[Photo H T Reeves]

The bracket fungus shown here lives on the material of the living tree. It is a parasite

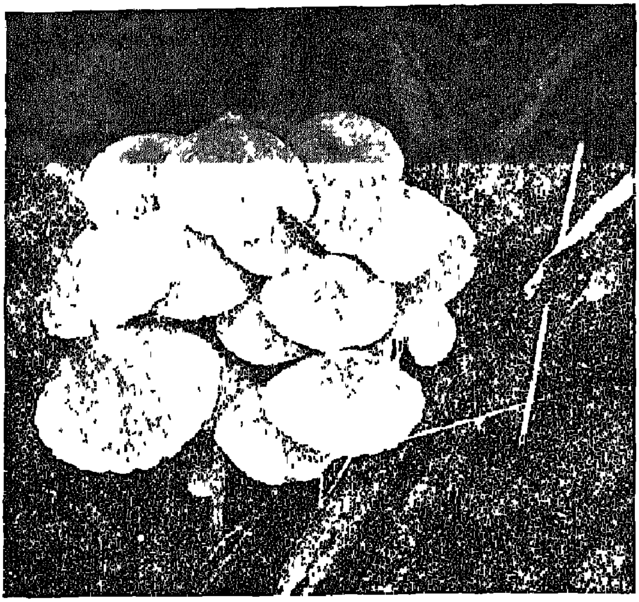
did make their own food and did have **chlorophyll,** but do not do so now.

This really means that a long time ago the ancestors of the fungi were plants which had green colouring matter and so made their own food Some of these plants were forced to live in places where there was not sufficient light and so they could not make their own food. Most of them died out but a few of them were able to go on living because they could use food already made by other plants, food in the form of rotting wood, perhaps, or even of living wood The young plants which were produced by these grew in the same places and were able to live in the same way

So we still call them plants although they do not make their own food but use food already made by plants, just as animals do

So we can say.

ANIMALS ARE DEPENDENT ON PLANTS FOR THEIR FOOD. PLANTS MAKE THEIR OWN FOOD FROM AIR AND MOISTURE IN THE PRESENCE OF LIGHT.



[Photo H T Reeves]

Toadstools live on decaying material The part which you see *in the picture bears the "spores"* which are able to grow into new toadstools if they get sufficient moisture and decaying material The plant starts its growth as a number of fine threads pushing their way through the moist material

None of these plants have any chlorophyll or green colouring matter, so they are dependent on material which has at one time formed the body of other plants and animals In this way they are like animals But we cannot call them animals because we know that they have adapted themselves to live in this way for special reasons Their ancestors did have chlorophyll and lived an independent life but were forced by circumstances to abandon this way of living

[Photo H T Reeves]

FAIRY RINGS

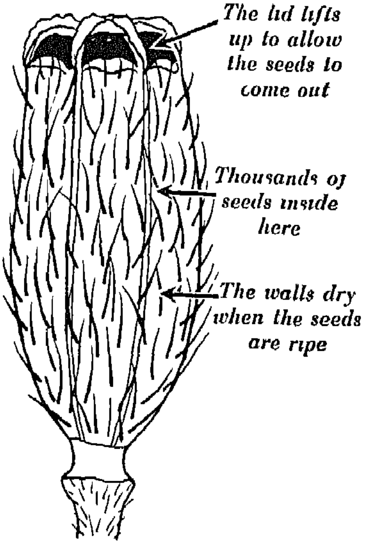
Have you ever seen mushrooms or toadstools growing in a ring like they are in this picture? It is easy to understand that all sorts of myths have grown up as to how and why they grow like this—that they grew up where the fairies had been dancing or that they show the path the devil took while he was churning butter

But you know that the mushrooms or toadstools spring up from fine threads in the ground Sometimes these threads start at a single point where there is some rotting material in the soil As it uses up this material it grows outwards in search of more, and the central part dies away So the circle grows and grows in much the same way as the roots of a plant spread outwards from the trunk

UNIT 3

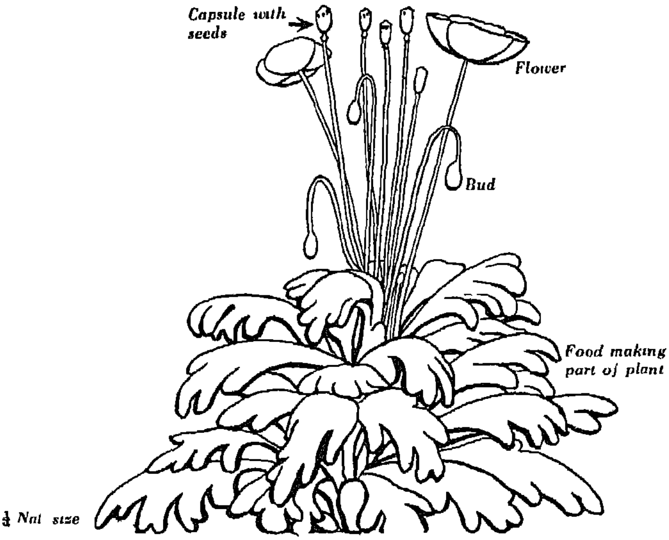
How do Living Things Protect Themselves?

Here's a **poppy capsule** or seed box for you It is just ready to open to allow the seeds to come out. These seeds, as you know, can grow into new poppy plants Now the poppy seed box has a great many


The lid lifts up to allow the seeds to come out
Thousands of seeds inside here
The walls dry when the seeds are ripe

Four times Nat size

seeds in it—many thousands. And there are many seed pods on one poppy plant, aren't there? And there are a great many poppy plants in one single garden very often, aren't there? This means that if you grow a bed of poppies and leave just a few of



A single poppy plant produces some millions of seeds
They cannot all produce new plants

the seed pods to mature you will allow millions of seeds to escape How is it, then, that your whole neighbourhood isn't covered with poppy plants the next year? A great many things may happen The seed may not all be fertile (able to grow) Some of the seeds may fall on dry ground, on a concrete path or some other place where they cannot grow. Some of the seed may be eaten by ants or by slaters. But some seeds will probably grow Of these some may fall on exposed soil which dries up and so kills the plant Some may be swamped with rain and so die Some seedlings may be eaten by snails, others by birds. Some may be trampled underfoot by you or your friends as you go to and fro Indeed, there are many hazards for the plant before it reaches maturity.

So it is with all living things In order to live successfully they have to struggle against great odds

Most of them die before they grow up If they all die, of course, there will be no more of that particular kind of plant or animal This does happen every now and then More frequently, however, out of the millions of seeds or eggs or live young produced, only a small percentage lives to grow up

But this small percentage is sufficient to carry on the life of that particular plant or animal This small number, in its turn, produces a very large number of offspring, most of which fail to develop When we see a self-sown bed of marigolds, for example, we marvel at their number, but we forget, sometimes, the very much greater number of seeds which never had any chance to grow at all.

It is an interesting experiment to sow a handful of easily-grown seed in a seed-box and watch what happens if they are unweeded Count the seeds you sow. Count the number of seedlings that come up Every few days take another count and so on until your plants have either all died out or one or two have struggled to maturity.

Let us have a look at the way in which some plants and animals protect themselves Animals which, as you know, live on animal food or on plant food, usually move about to find their food Animals which serve as food for other animals are often chased by them. Such animals have to protect themselves against their enemy food-catchers Plants have to protect themselves against food-eating animals, too Plants and animals often have to compete with one another for food, too If there are many animal-eating animals living in one district you will find that the best equipped ones will get food, while the others will not, unless food is very plentiful Plants living on the same area of ground often struggle for their existence, the stronger seedlings choking out the others

Then, of course, plants and animals have to protect themselves against adverse conditions of their environment, or the place in which they live Sometimes it is against extreme cold, or extreme heat, or hot, drying winds, or excessive rains Sometimes it is against extreme dryness, sometimes against hailstorms.

Sometimes it is against animals which eat them, or animals which tread them down. Sometimes it is against other plants which shut out the light or take too much nourishment from the soil

Plant and animals have learned to struggle against these adverse things in many different kinds of ways Some are more successful than others The most successful ones are what we call hardy plants or animals; those which have only partly succeeded are weak or delicate And those which have not succeeded have disappeared altogether Plants and animals which have learned to adapt themselves to unusual or new conditions are the sort of living things which become pests or weeds These sometimes spread over vast areas, over whole continents, or from land mass to land mass Can you think of some?

Now that you have some idea of the things which plants and animals have to struggle against we might take an excursion to see what we can find out about how some living things succeed in this We will plan our excursion for a hot, summer day We will find many things of great interest which do not help us to solve the problem of how plants and animals have succeeded in their great struggle against adverse conditions, but these other interesting things we will examine more closely on other occasions At first we shall just look closely and see what we can discover. Then we shall try to classify the things we have discovered.

THE WORLD OF LIFE IN A POOL.

(See coloured plate opposite)

A pool can be a little world of its own, quite independent of the outside world In it you will find many creatures, protected in all sorts of ways from their likely enemies and provided with all sorts of means of getting their food A quiet little pool, indeed, but see what lurks in its depths!

Look at the picture on the opposite page and see a few of these pond creatures and the way they live.

1 The **water beetle** is a quick-moving insect which can dive to protection, carrying with it a bubble of air so that it will not have to rise to the surface too speedily Its hard wing covers are a protection also.

2. The **may-fly** larva is concealed against a background almost its own colour Unseen it may dart swiftly upon any unsuspecting creature swimming close enough to it

3 The **caddis worm** or caddis-fly larva makes itself a coating of pebbles stuck together with a secretion from its own body In this one the head is protruding

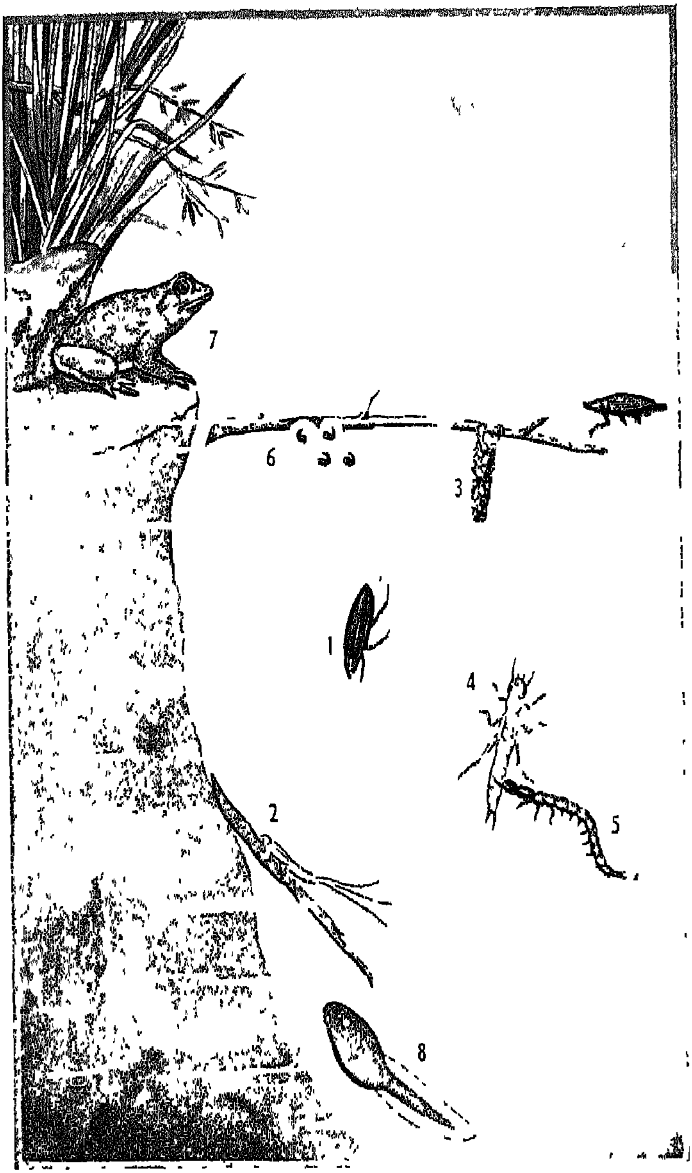
4 The **dragon-fly larva** is a fierce creature, darting about swiftly and grabbing its prey Its swift movement is its chief means of defence

5 The **water tiger,** the larva of a water beetle, is another swift, fierce creature of the pond

6 **Toads' eggs** are protected both from drying up and from being eaten by being covered with jelly It is not easy to grab a lump of jelly in the water!

7 **The toad** conceals itself very effectively against its background Many creatures possess this power of merging into different backgrounds

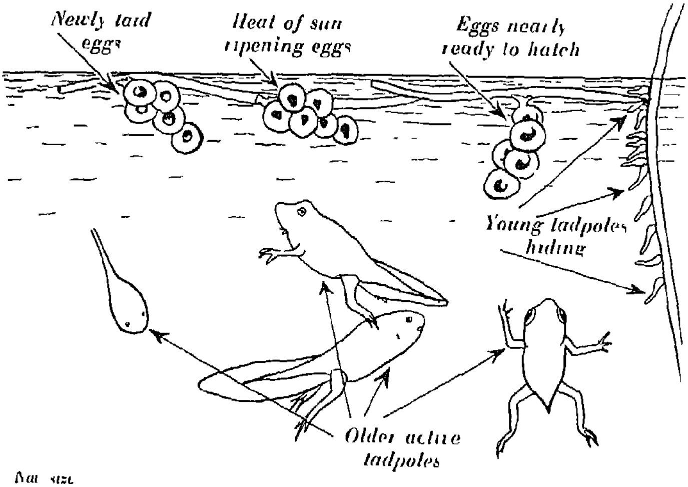
8 **The tadpole** is active and strong and very slippery



The World of Life in a pool

An Excursion.

We made our way first to a little pool in the shade of some overhanging trees Floating just below the surface were some long strings of **toad's eggs** or **spawn,** masses of jelly surrounding a central black and white part Looking more closely we could see the outline of the tiny toad tadpole within the jelly, a little curled up creature nearly ready to emerge It was easy to see from this that the young tadpole was not taking any nourishment from the jelly surrounding it What, then, was its purpose? Peering again into the pond we observed where the spawn was lying The heat of the sun, we knew, helped to hatch the eggs, so we were not surprised to find that most of the eggs were lying where the sun could reach them Many were lying partly out of water so that they gave us part of an answer to our question. The jelly



How well the toad is protected against his many enemies in all the stages of growth

C

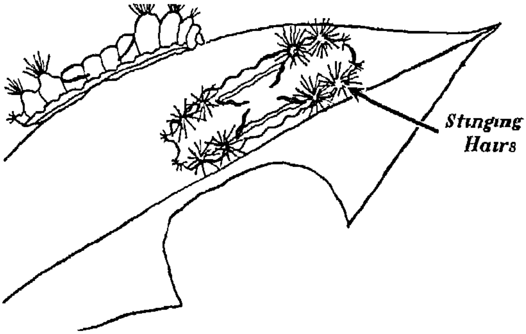
prevented the eggs from drying up when they were exposed. We remembered that toads and frogs sometimes lay their eggs in pools of water which dry fairly quickly if rain does not fall and this protection against drying up would save some of the eggs from destruction.

There is another use for the jelly, too. All eggs are good food, because they have stored nourishment for the young. So eggs have to be protected against enemies which would eat them The jelly round the toad's eggs make it difficult for birds to swoop down and pick them up, so it acts as a protection in this way.

While we were watching the toad's eggs we noticed some very small tadpoles and some larger ones Catching them—and this was not easy with the larger ones—we noticed that they were slippery, too, and we thought that this slipperiness would also serve to protect them against being eaten. The larger ones darted about very quickly, a useful protective measure, and, when they came to rest, lay still in the shady part of the pool, making it very difficult to see them through the still water This would also help to protect them. The very tiny ones, we noticed, did not move, but hung on to pieces of grass floating in the water, so still that it was very difficult to see them And while we were still exploring we saw a little fawn toad sitting quite still against the rock at the edge of the pool. He was so well camouflaged I don't know how we saw him at all.

Darting about on the top of the water were some **water boatmen.** We tried to catch them but it was too difficult Their flat bodies, for they are really true bugs, skimmed the water with great rapidity, a very successful method of protection for an animal which lives in such an exposed place as the water boatman

Another pond animal which uses rapid movement as a means of protection is the **diving beetle**, which darted down into the water while we were watching. A bubble of air at the tip of the body helped to supply oxygen for breathing We caught him and looked closely at him. We noticed that his hard wings would also be a great protection, for many birds would find it very difficult to peck through them Then we noticed, too, a bubble of air under his wing cover, and so we discovered the secret of how he can stay under the water so long—he carries air with him as a **protection against drowning.**

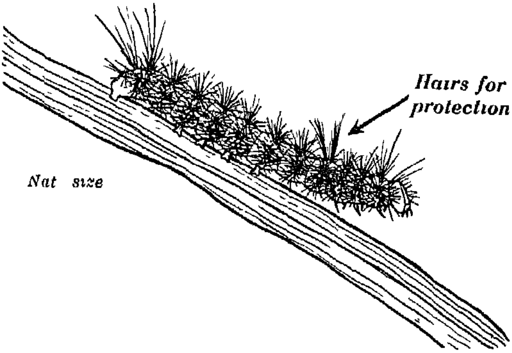


Nat size

The caterpillar of the cup moth can give a very irritating sting This is a great protection against enemies which would eat it

After that we left the pool and began searching on the leaves of the trees and bushes We found quite a number of **moth** and **butterfly eggs**, nearly all of them laid on the under-surface of the leaves Here again eggs have a great deal of nourishment in them and would be good food for birds, but birds will not find them so easily if they are on the under-surface

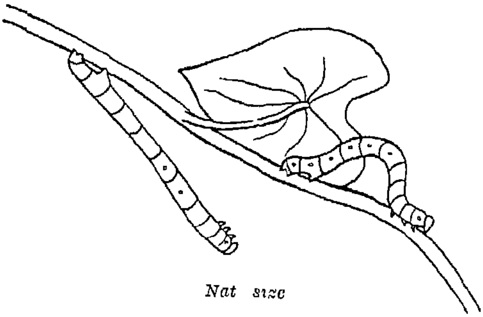
While we were looking at the leaves one of the children cried out and we discovered he had been stung by a **cup moth caterpillar.** We were sorry because the sting is very nasty, but it is not dangerous. We put some ammonia on it to take some of the pain away. We always carry this in the bush in case of just such emergencies When he was feeling a bit better we had a closer look at the **cup moth caterpillar.** It is a very beautiful creature with four sets of hairs, two at each end of its body. As soon as we touched the leaf to which it was clinging it raised these hairs and shot out some of its stinging fluid But we were very careful not to get it on ourselves You can imagine that not many animals would risk such a sting for a meal and so the **cup moth caterpillar** can afford to be conspicuous.



Very few birds will eat a hairy caterpillar like this one

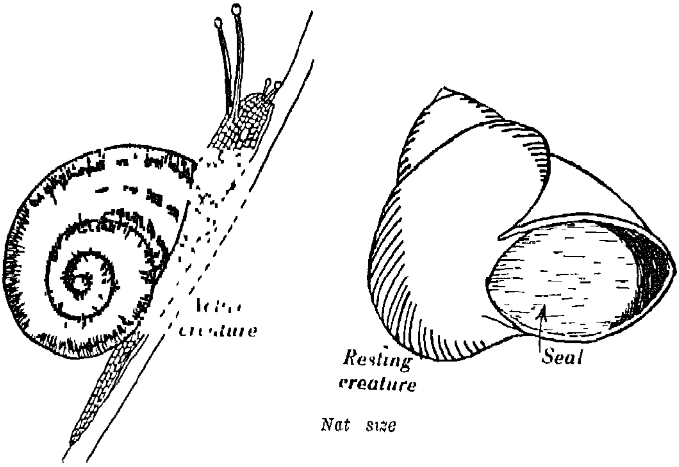
On the grass down below the tree we saw a very woolly **caterpillar** eating away without troubling to conceal himself at all Very few animals will eat woolly **caterpillars**, they are so disagreeable going down. And on a cotton bush close by we saw the caterpillar of the **Wanderer or Monarch butterfly**, a very conspicuous creature with black and orange stripes Most animals are wary of brightly-coloured living things, probably because many brightly-coloured animals are poisonous

On a twig of another plant nearby we saw something which we very nearly missed—a brown **looper caterpillar** lying straight out against the twig and looking for all the world like a twig himself If he had commenced eating he would have been noticed at once, and his smooth, soft body would have made the beginning of a fine meal for some small bird So he waits for dark before he commences to feed and remains stiff and straight like this in the daytime.



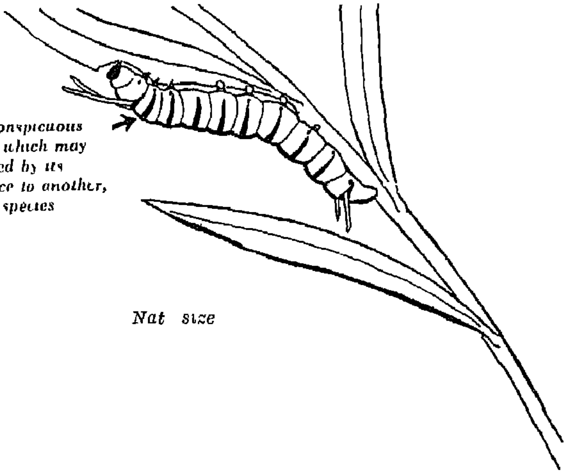
It is very difficult to see a looper caterpillar at rest Often it is the exact shade of the stem on which it rests The strong muscles of its body enable it to remain motionless for long periods

Then we commenced to look under rocks and stones, favorite hiding places for lots of small things. It was very hot, indeed, and there had been no rain for some time We found a batch of **snails** and every one of them had sealed up the entrance to his house as a protection against drying up. **Snails** have to have a good deal of moisture to live an active life When there is not enough moisture they close up their doors and wait for things to get better. They do this in



The snail crawls actively when in search of food If it needs to protect itself it crawls into its shell and, if this is for any length of time, it seals the shell In very cold or dry weather it does this

very cold weather, too You may wonder how they manage about air for breathing If you look carefully on the left-hand side of the snail, just outside the shell, you will see a small opening in the skin This small opening leads into a breathing cavity and, by this means, the snail normally gets sufficient air for its slow activity. When it seals itself up for protection it leaves this opening exposed, and a small, but continuous, current of air passes into it all the time We noticed, too, the hard protective shell which prevents it from being eaten And we remembered that snails mostly feed at night when they are not so easily seen. So we were not surprised any longer at their success! Some clever birds have learned to smash the shells of snails on rocks and so get at the succulent body inside. Watch and see whether you can discover what sort of birds do this This is an example of one

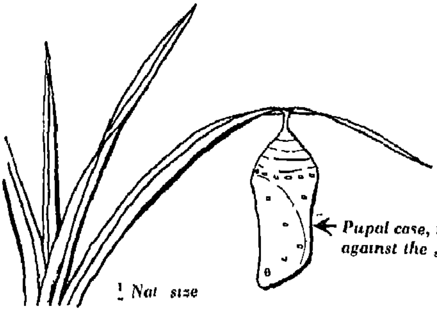


Smooth, conspicuous caterpillar which may be protected by its resemblance to another, poisonous species

Nat size

The Wanderer or Monarch butterfly has a very conspicuous caterpillar but it is rarely attacked by birds, although it has a smooth body Its colouring is somewhat similar to that of another caterpillar which is poisonous and so avoided by birds This resemblance may serve to preserve the Wanderer

The pupa is usually protected against a grass of the same colour or by being well hidden in foliage

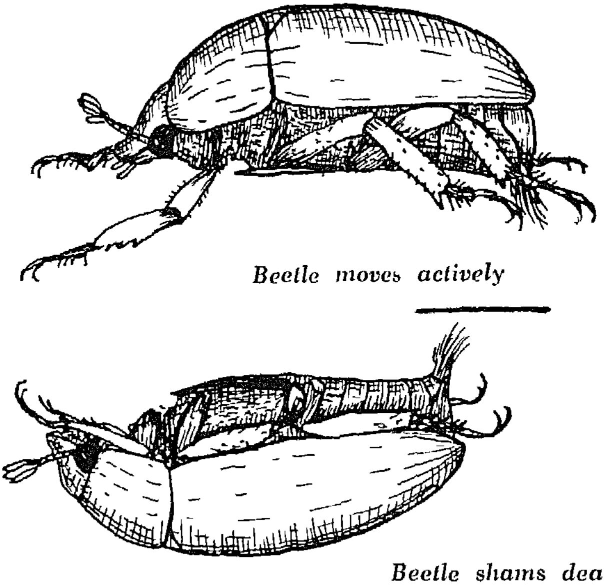


Pupal case, not very conspicuous against the green grass

½ Nat size

of the many struggles which is going on continuously in nature—one form of protection is developed and another living thing finds out how to overcome this in order to go on living itself

Under the same stone we found the tangled web of a **red-back spider** and, hiding in a crevice, the lady



Cockchafer beetle protects itself
by shamming death

herself We knew that her poisonous property protected her and we were a little surprised to find that she made no attempt to attack us Indeed, when we prodded her she pretended to be dead, if you please. Then one of the boys remembered that this was a favorite dodge with the **Cockchafer beetle,** too

You will be interested to know something about the poison of the **red-back spider.** It is very poisonous, indeed, and there seems no doubt that a bite from one can cause the death of a human The **red-back** is one of our commonest spiders and you may wonder why it is that you so seldom hear of people being bitten. The reason is that the lady is very retiring indeed, and lives in dark, secluded places Moreover, she is not at all aggressive, preferring to hide herself away or to pretend to be dead if danger is near It is only when there seems no other way that she uses her powerful weapon. Apart from the presence of this poison the animal is helpless, being soft-bodied, and she would often be killed if she did not protect herself by hiding in this manner You can always tell a red-back spider's web. It is very irregular and tangled, and you will find it in dark places like the corners of dark outhouses, under flower-pots and the like If you are hunting in places where **red-backs** are likely to be, keep a sharp lookout for them and be sure to kill them. There is no danger if you are ready for them, but never thrust your hand carelessly into a corner where they might be.

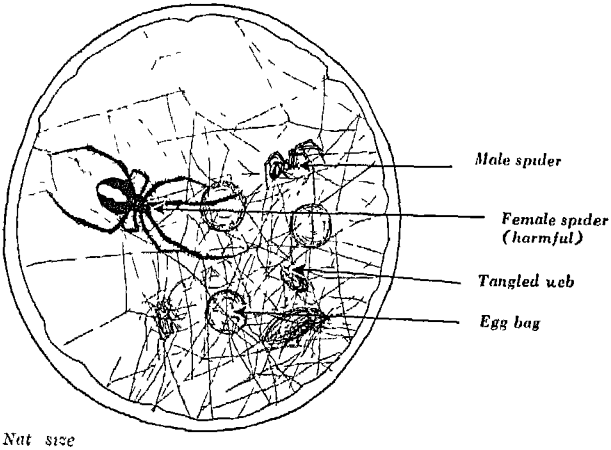
Nat size

The Redback Spider will often pretend to be dead when it is in danger

It is always the female spider which is known as the **red-back.** The male is very small, only about one-quarter the size of his spouse, and quite harmless You very rarely see him because, after he has lived a few days, lady wife usually devours him.

Nearby were a group of **goldfinches** eating grass seed As we approached one gave the warning cry and a host of small birds rose into the air This community feeding and protection is a not uncommon method by which animals protect themselves

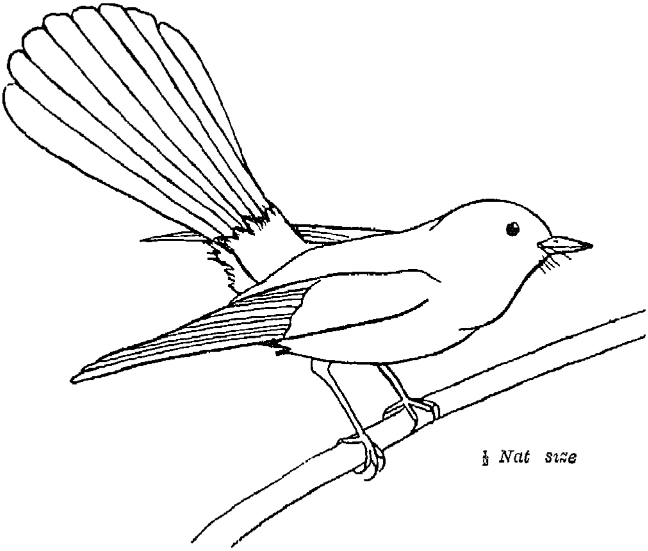
Searching among the grass we found a number of the beautiful **cocoons** of the **Wanderer butterfly,** their greenish colour mingling with the grass in such a way as to afford protection We noticed, at the same time, that the **cocoons** were suspended on the stems so that the butterflies would have no difficulty in emerging. While we were thus employed our attention was drawn



½ *Nat size*

The tangled web of the Redback Spider

to the fussiness of a Willy Wagtail apparently trying to divert our attention From some distance away, whence we wandered to watch, we noticed the bird fly into a tree quite near where we had been standing We returned to observe what had passed by unnoticed before—a nest with two young Willies in it No doubt the mother had been trying to protect them from harm This parental instinct, most commonly devel-

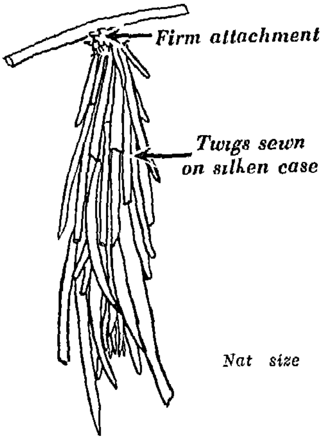


The Willie Wagtail is adept at attracting attention to herself in order to divert it from a nestful of her babies

oped in the higher animals and particularly among humans, is a very powerful protective factor. Even if it leads to the death of the parent animal it may succeed in preserving the young, and so the race will be preserved A great many birds have it very strongly developed, appearing to be quite careless of their own safety while that of their babies is at stake I have seen a ground plover, with young in the nest, trail a wing on the ground for a considerable distance, pretending to be injured. This was apparently in the hope that the attention of the humans would be diverted away from the nest and so the babies would be safe

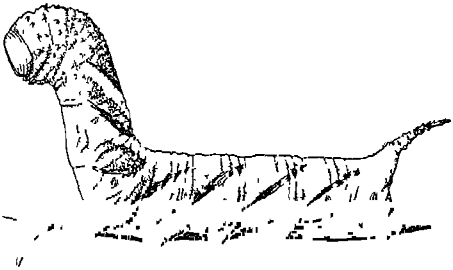
So we wandered on, still watching We found a **casemoth** suspended from a twig and greatly admired the protection of the tough coat to which sticks had been attached, both for direct protection and probably for camouflage.

A fawny grey-coloured caterpillar of the **gum tree pinara** reared its head as we touched it It brought the lower part of the head downwards, revealing two eye-like markings. In this position it looked menacing enough to frighten off any bird who had thought to pick it off the bough. Lying along the bough its protective colouring merged extraordinarily well with the bark Close by, too, on the main stem of the same tree, we noticed a **moth** resting with its wings spread. So nearly did it resemble the bark that the closest inspection was necessary to discover it



The tough case of the Casemoth with its camouflaging twigs is a very effective protection to it.

A short distance away—it was now getting towards dark—a young **rabbit** darted swiftly away into the undergrowth We noted the rapidity of its movement as a protection. But we also noted the conspicuous bobbing white bunch of a tail and wondered whether it might not act as a warning to other rabbits in the same vicinity Certainly we saw another one dart off in the same direction as the first, and very soon after This warning given by one animal to another of the same kind is not uncommon in nature It is important in the preservation of many animals of the same kind or species.



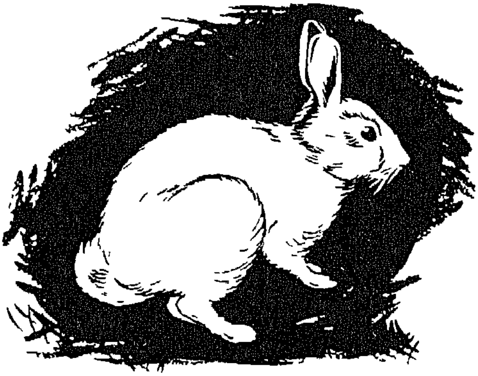
[Block by courtesy Australian Museum]

Nat size

The menacing attitude of this caterpillar is a great protection

We were so intently watching the rabbits that we almost failed to notice a **Blue Tongue lizard** sitting quite motionless on a rock nearby At first we thought he must be dead, he was so very still. But as soon as I moved across to touch him off he darted, safely, to the protection of the bush This capacity to remain quite still as a means of protection is by no means uncommon Very few animals will attempt to catch another animal who remains like this

Just as we were leaving for home one of the children called our attention to a **stick-like animal** which was clinging, suspended between two bare twigs. It was extremely well camouflaged The type of animal which is able to accommodate itself to its surroundings in this way is able to alter its colour in relationship



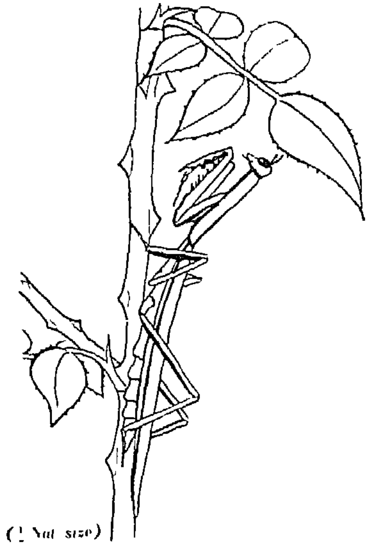
Much reduced

Bunny scurries through the darkness, his speed serving as a great protection His white bobbing tail is quite conspicuous and possibly serves to warn other rabbits of the approach of danger This community protection helps to preserve the race

with the conditions of its surroundings. It does not consciously do this, of course, but the effect of the light operating on it causes it to appear a slightly different colour in different surroundings. If this slight difference causes it to merge more closely into its environment it will obviously be less likely to be found and devoured by its enemies If, on the other hand, the difference made it more conspicuous than otherwise, it would be more easily seen by its enemies and be more likely to be eaten. So those which tend

[Photo K A Hindwood]

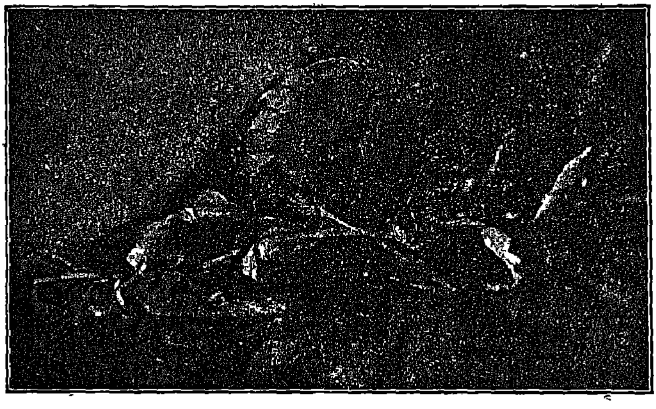
It is not easy to pick this broad-tailed gecko from its background Like many such creatures it has the capacity of altering its colour to some extent to merge into its background This, together with its capacity for remaining very still, is an excellent protective camouflage to merge into their surroundings would be most likely to survive, and those which did not would be most likely to be wiped out by being eaten This is happening in nature all the time The insect we had found was a **stick insect**, a close relative of the preying mantis



It is not easy to distinguish this mantis from the stem on which he remains quite motionless Unwary small animals may be caught by his strong front legs if they come too close

[Block by courtesy "Wild Life", Australian Nature Magazine]

A caterpillar of the Nola moth, rigid on a bough so that it resembles a curled leaf



[Block by courtesy Australian Museum]

The Leaf insect is well concealed on a leafy twig

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Now we have made a number of observations on the ways in which animals protect themselves, and it is time we classified them and arranged them in some sort of order First of all, let us make a list of them just as we saw them.

Animal	How it Protects Itself
Toad	Protects its eggs from drying up and from being eaten by having a jelly substance round them
Tadpoles	Have a slippery surface so that they cannot easily be eaten and hide in the dark parts of the pool when they are not feeding
Water beetle	Carries a bubble of air down into the water with him to protect him from drowning His hard outer wings protect him, too
Water Boatmen.	Move so quickly that they cannot easily be caught Their hard wings protect them, too
Moths and butterflies	Usually deposit their eggs on the under-surface of leaves where they cannot easily be seen
Cup moth caterpillar.	Has stinging hairs for protection
Tiger Moth caterpillar or Woolly Bear	The hairs make it unpalatable
Wanderer caterpillar	Its bright and conspicuous colour make birds wary of it
Brown looper caterpillar.	Resembles the twig on which it rests.
Snails	Have hard shells and close up the opening in the shell when the weather is hot and dry
Red-back spider.	Has a poisonous bite. Pretends to be dead Hides
Goldfinches	Hunt in packs and give one another the warning signal when danger is approaching

Animal	**How it Protects Itself**
Cocoons of the Wanderer butterfly	Concealed in the grass they resemble it in colour and so are camouflaged.
Willie Wagtail	Diverts attention from her nest to protect her babies from possible harm
Casemoth.	Conceals itself inside a tough case and puts small pieces of twig on the outside as a camouflage
Fawn-coloured moth	Resembles the bark on which it rests
Pinara caterpillar.	Adopts a menacing attitude when it thinks it is in danger Resembles the bough on which it rests
Rabbit	Runs quickly from danger Perhaps warns its fellows by its bobbing tail
Cockchafer beetle.	Pretends to be dead.
Blue Tongue lizard.	Remains quite motionless pretending to be dead, and then darts quickly to shelter.
Stick insect	Resembles the twig to which it is clinging
Caddis worm.	Covers its body with particles of sand which it sticks together so that it is hard to distinguish from the sandy bottom of the pool

[Photo H T Reeves]

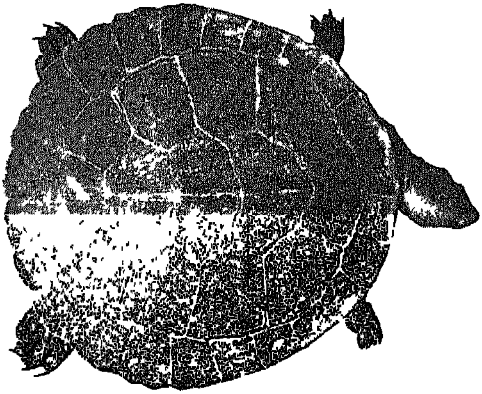
The Possums feed on plants and are nocturnal animals They have no other very effective way of protecting themselves against enemies but their thick furry covering is a good protection against change in climate and so enables them to move about in the night-time without coming to harm This one is the Short-Eared Possum (Trichosurus caninus)

Now let us rearrange them according to the way in which they protect themselves.

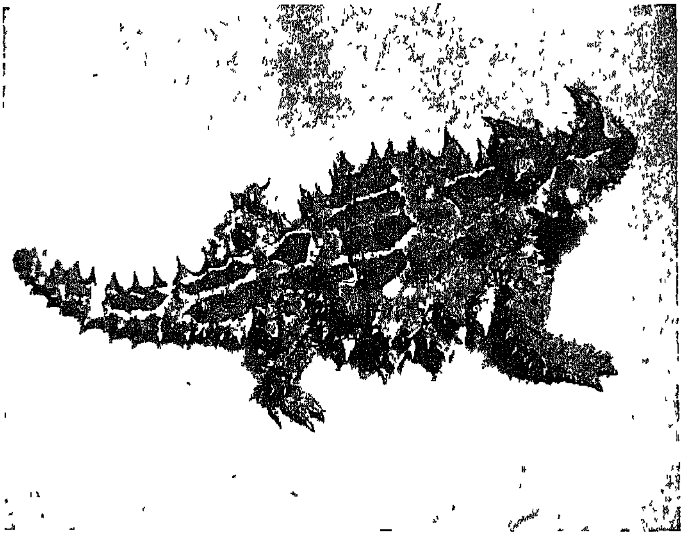
We will get something like this.

How Animals Protect Themselves

A From drying up	B From being eaten by their enemies.
1 Toads' eggs	1 By having a jelly-like covering— Toads' eggs
2 Tadpoles	2 By being concealed— Tadpoles Water boatmen Water beetle Goldfinches Rabbits Blue Tongue lizards Eggs of butterflies and moths
	3 By having a protective cover— Beetles Water boatman. Snails Casemoth
	4 By having a poison or a sting— Cup moth caterpillar Red-back spider
	5 By being unpalatable or seeming to be so— Woolly bear caterpillar Wanderer caterpillar
	6 By camouflage— Some moths resemble their surroundings Looper caterpillar resembles twigs
	7 By pretending to be dead— Cockchafer beetles Red-back spider
	8 By warning each other— Rabbits Goldfinches
	9 By protecting their babies— Willie Wagtails
	10. By looking ferocious— Pinara caterpillar.

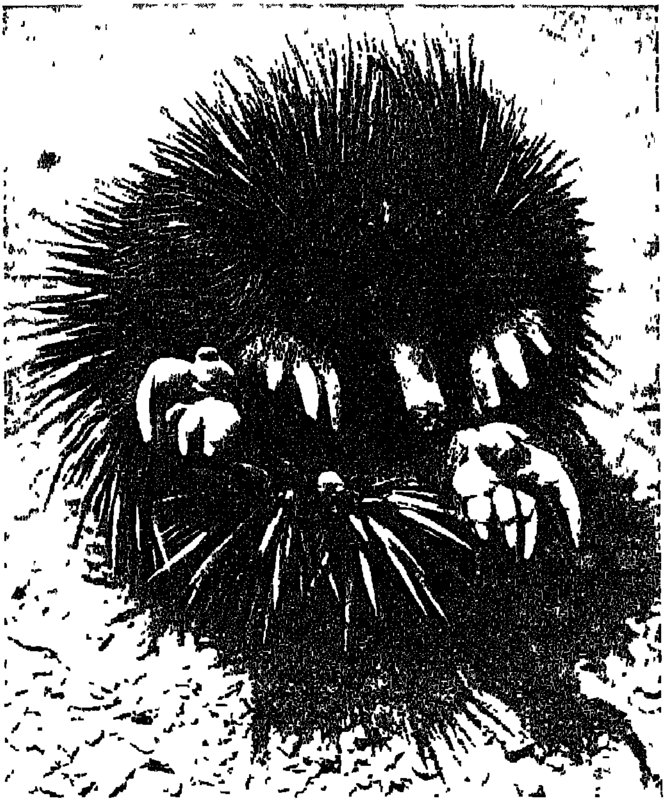


The Murray River Tortoise or Turtle is protected, like all such creatures, with a heavy shell beneath which the animal may conceal his whole body if he is in danger of attack



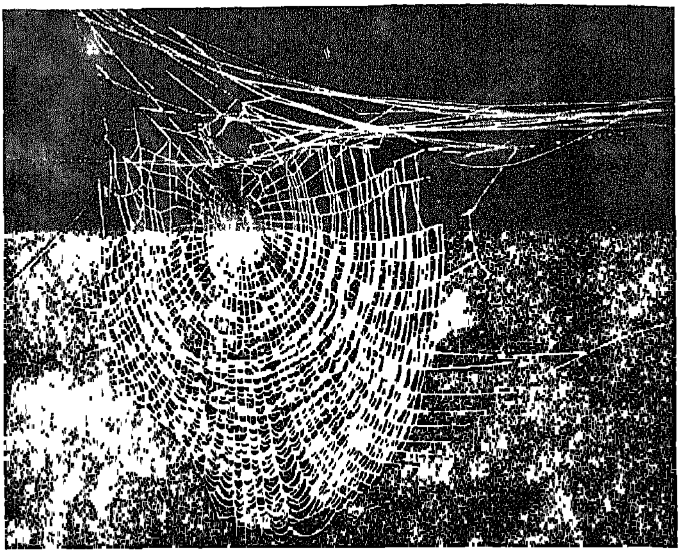
[Photo H T Reeves]

The Horned Dragon or Mountain Devil is well protected by this spiny coat and fearsome appearance He is only a little chap, a few inches in length, and is really quite harmless but he certainly has earned the name "horridus" (his name is Moloch horridus) by his ferocious appearance. He belongs to the inland parts of Australia



[Photo O A Sims]

The Spiny Ant Eater or **Echidna** is, in this position, a fearsome ball of spines and claws In danger of attack he will often roll himself into a ball and present his back to the enemy But if he is forced to attack he will often adopt this menacing and effective attitude



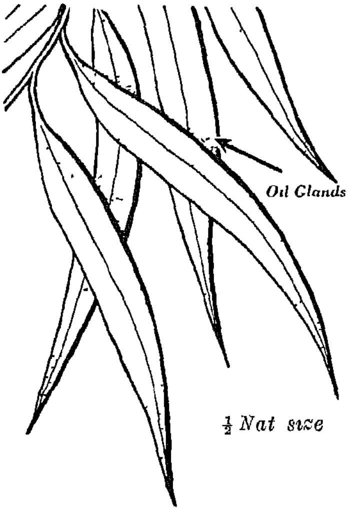
[Photo H T Reeves]

The web of a spider is not very conspicuous to small insects on the wing The spider itself is usually well concealed but watchful, in a good position for tightening the thread if it catches a victim The web is very strong and is not, therefore, easily broken Some spiders take up a position in the centre of the web but remain very still so they are not easily seen

Plants Also Protect Themselves.

While we were exploring we also looked to find out how plants protect themselves. We noticed that many of the plants, like **flannel flowers**, had furry coverings over their leaves and that these plants were not eaten by caterpillars and other animals So the furry covering over the leaves protects as the furry coat of the caterpillar protects. Other plants, like the **thornbush**, we saw had sharp thorns and this would make it very difficult for grazing animals to eat.

Among the big trees many were badly eaten by the cockchafer beetle, but some, perhaps because of the high oil content of their leaves, were not eaten at all. A row of **lemon-scented gums** which had been planted on one side of the gully we were investigating had hardly been touched



The oil glands in the leaves of the **Lemon Scented Gum** serve as a protection to the plant against some animals like beetles which dislike the taste of the oil

Plants need to protect themselves against drying winds, too The dominant or strongest wind in this area is the southerly and, on the exposed side, we saw that the trees were bent away from this direction, so protecting themselves against its harmful effects. On the hillsides where the wind blows fiercely and the soil does not hold moisture very well, many of the plants, like **Banksias**, have hard leaves which will endure such conditions Where the light was poor, in the densest parts of the gully we noticed that the plants were very tall and thin, reaching up to the light, or had climbing stems or divided leaves like **ferns,** so that they could get the most light as it filters through the branches of the tall trees

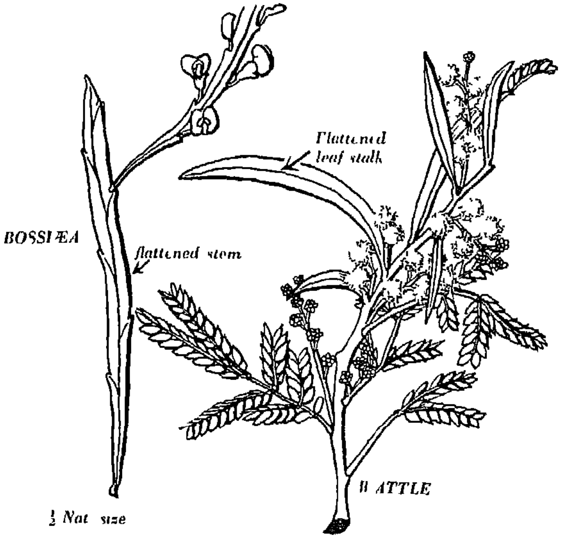
In Australia there are a great many areas where plants have to protect themselves against drought In Sydney, for instance, although the rainfall is not

Dillwynia has very fine leaves, closely crowded together, and this helps it to conserve water There are only a few openings on these fine leaves and, being so close together, they prevent much evaporation

½ Nat size

very low, nearly 47 inches in a year, hot, drying winds help to dry it up from the ground and from the plants. In addition, a great deal of the soil is coarse and sandy and the water quickly runs away. So a great many plants have to protect themselves against loss of water. Water is evaporated from plants mainly through tiny openings on the leaves which also allow gases for respiration, or breathing, and food making, to pass in, and waste gases to pass out The evaporation of the water from these openings helps to keep a constant supply of water travelling through the plant and up to the leaves, in the same way as you keep a supply of lemonade travelling through a straw as you suck it from a glass. The plant, too, usually needs to take in a good deal more moisture than it actually requires in order to get sufficient mineral salts from the soil.

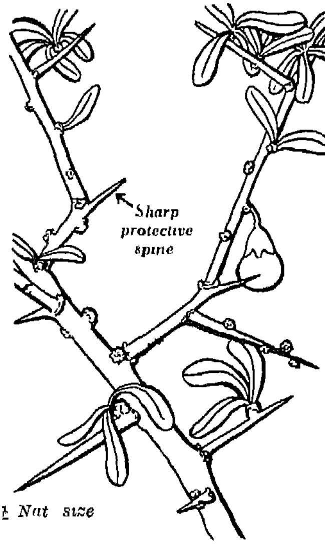
Many Australian plants have learned to reduce the surface through which this evaporation takes place.



Flattened stems (cladodes) and flattened leaf stalks (phyllodes) have less openings in them than leaves of equal size, and so less water is lost by plants which have these structures

Some plants, like **Dillwynia (Eggs and Bacon),** have a large number of very fine leaves so that there will only be a small number of openings on each tiny leaf

Others, like many **wattles,** have flattened the leaf stem, which contains relatively fewer openings than the leaves, and has used this flattened leaf stalk instead of a leaf The true leaf of the **wattle** is fern-like, the flattened leaf stalk may be many different shapes according to the type of **wattle.** In the one illustrated you will see that the flattened leaf stalk is long and narrow and that on some branches the feathery leaves are still to be seen In the seedling stage of such **wattles** you will always find some feathery leaves, but on the mature plant you will usually find only flattened leaf stalks In the one

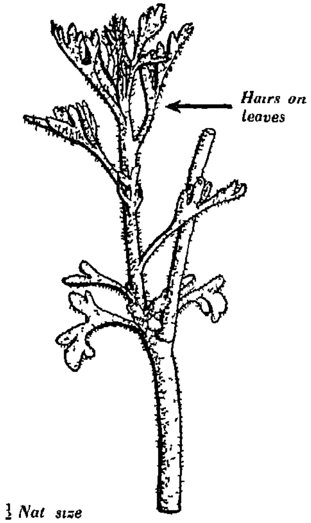


A thornbush (Solanum) which protects itself from being eaten by the presence of thorns

which has been illustrated for you there are flattened leaf stalks and true leaves on the same mature branch.

Some other plants overcome the difficulty by flattening the whole of the stem of the plant and doing away with leaves altogether. Here, also, the stem has fewer openings than the leaves and so evaporation is lessened The plant in the illustration which shows this feature is another kind of **Eggs and Bacon.** It is called **Bossiæa** and is very common on the sandy soil round Sydney and on the Blue Mountains

So we discovered that plants, too, have to protect themselves



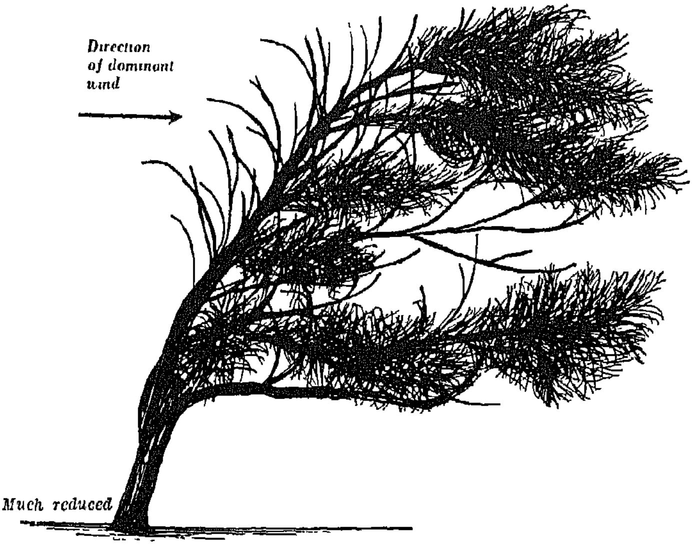
Flannel flower leaves are protected by a thick covering of hairs

Let us summarise what we have found out about plants.

Some plants have leaves covered with hair so that they will not be eaten

Some plants have spines so that they will not be eaten

Some plants have oil in their leaves which animals like caterpillars find distasteful and so they are not eaten.



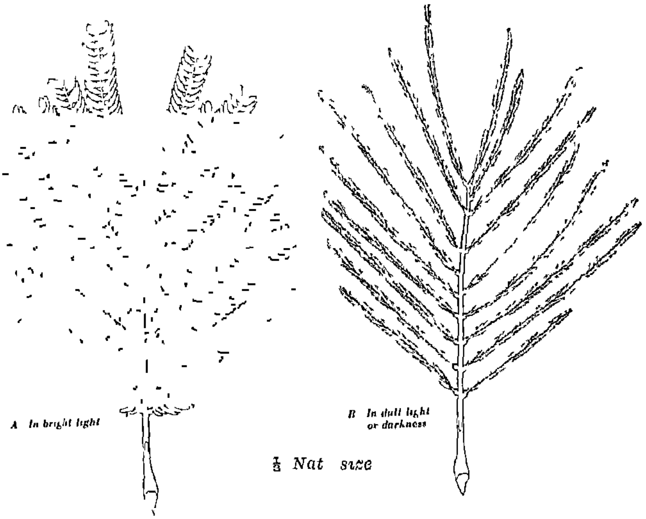
The She-oak, which has learned to bend away from the direction of the dominant wind, and so protect itself

Trees exposed to strong winds grow away from the direction of the wind as a protection

Some plants protect themselves against drying up by having hard leaves.

Plants protect themselves against poor light conditions by growing very tall or having climbing stems or by having divided leaves

Some plants have very fine leaves to reduce the evaporating surface, others replace the leaves by flattened leaf stalks or flattened stems.



The leaves of many plants, such as this Albizzia (a plant related to the Acacias or Wattles) assume a protective or sleep attitude during dull or dark weather and at night In this way they are less conspicuous and probably, therefore, less likely to be attacked by enemies which would otherwise eat them Since there is not sufficient light for them to manufacture food they lose nothing by folding over

We can now divide our plants into groups as follows —

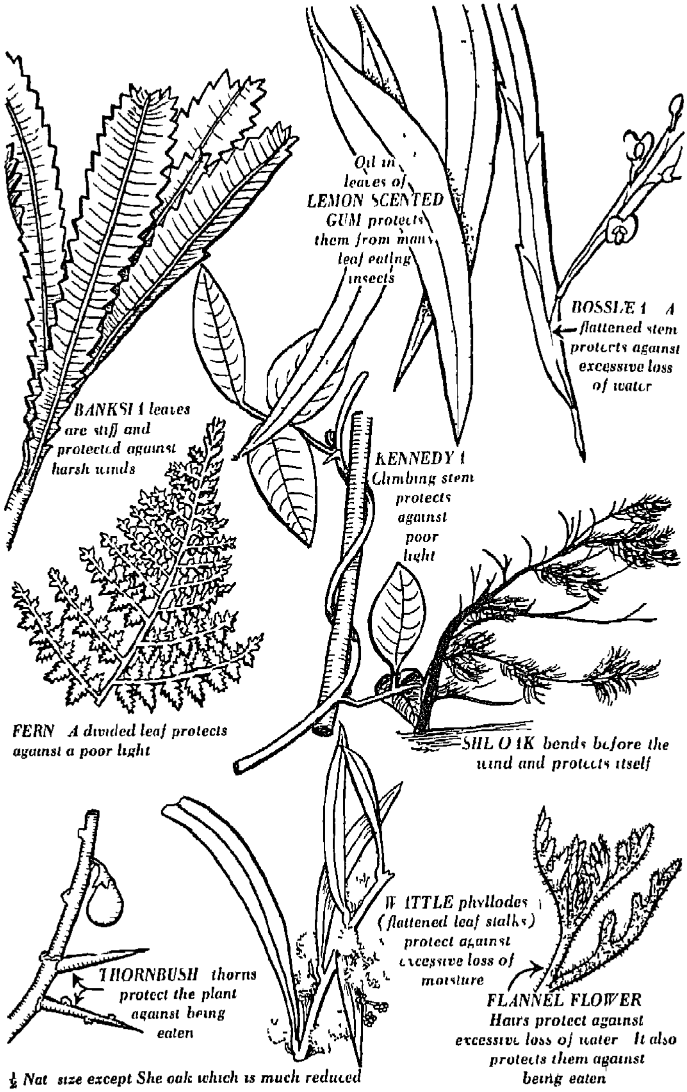
How Plants Protect Themselves

A. From being eaten by animals—

1. By having a covering over the leaves (Flannel Flower).
2. By having thorns (Thornbush)
3 By having strong oil in the leaves (Lemon-scented Gum)

B. From drying winds—

1. By growing away from the wind.
2 By having hard leaves.


Oil in leaves of LEMON SCENTED GUM protects them from many leaf eating insects
BOSSIÆA A flattened stem protects against excessive loss of water
BANKSIA leaves are stiff and protected against harsh winds
KENNEDYA Climbing stem protects against poor light
FERN A divided leaf protects against a poor light
SHE OAK bends before the wind and protects itself
WATTLE phyllodes (flattened leaf stalks) protect against excessive loss of moisture
THORNBUSH thorns protect the plant against being eaten
FLANNEL FLOWER Hairs protect against excessive loss of water It also protects them against being eaten

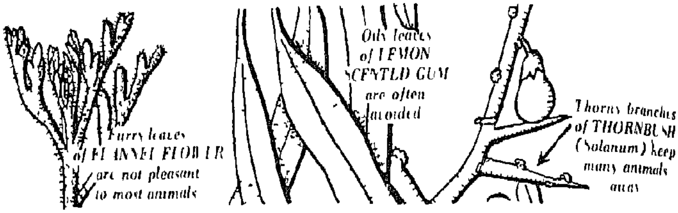
½ Nat size except She oak which is much reduced

Some ways in which plants protect themselves

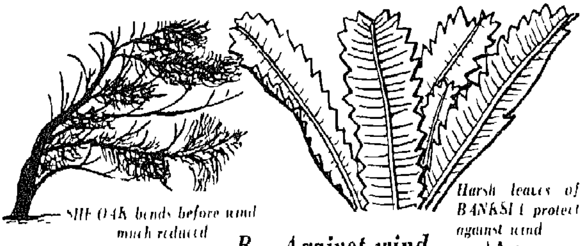
C From poor light—
  1 By growing very tall.
  2 By having a climbing stem.
  3. By having divided leaves.

D. From too high evaporation—
  1. By having fine leaves.
  2 By having flattened leaf stalks instead of leaves
  3 By having flattened stems instead of leaves

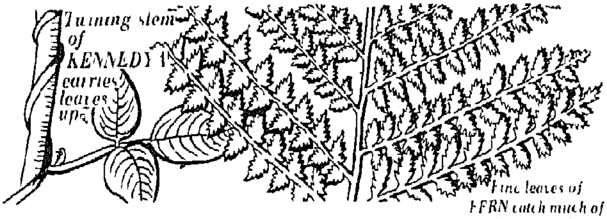
Now it is time for you to take some excursions and make some discoveries for yourselves. You can find examples of the things we have been talking about and many others besides, in the garden, in the park, in the bush, by the seashore and almost anywhere you like to look I suggest you make a start just the way we did First of all, have a good look wherever you can and make a note of your observations Then classify them like we did and see how many different ways you can find of how animals and plants protect themselves.


Furry leaves of FLANNEL FLOWER are not pleasant to most animals
Oily leaves of LEMON SCENTED GUM are often avoided
Thorny branches of THORNBUSH (Solanum) keep many animals away
½ Nat size

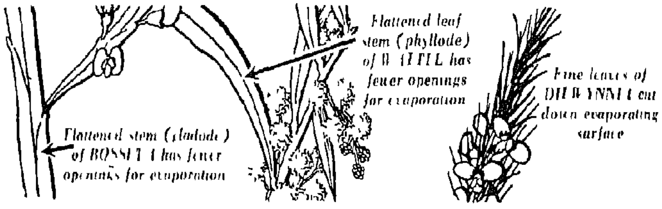
A Against plant-eating animals.


SHE-OAK bends before wind much reduced
Harsh leaves of BANKSIA protect against wind
½ Nat size

B. Against wind.


Twining stem of KENNEDYA carries leaves up
Fine leaves of FERN catch much of light which filters through
½ Nat size

C Against poor light.


Flattened stem (cladode) of BOSSIAEA has fewer openings for evaporation
Flattened leaf stem (phyllode) of WATTLE has fewer openings for evaporation
Fine leaves of DILLWYNIA cut down evaporating surface

D. Against excessive loss of water.

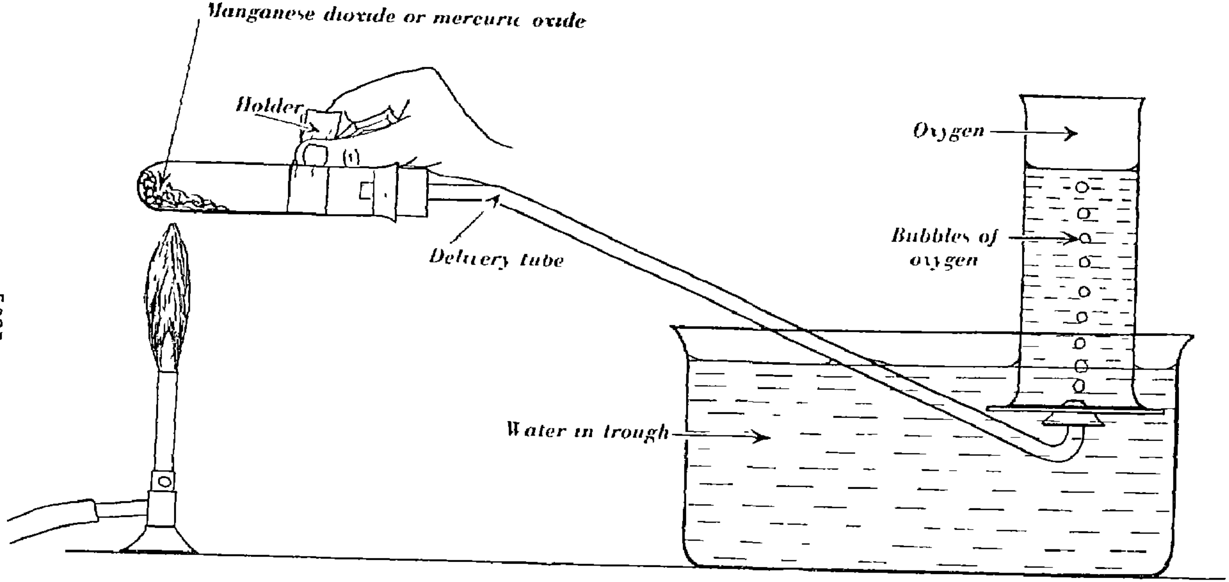
½ Nat size, except She-oak, which is much reduced

Plants have to protect themselves against various agencies

UNIT 4

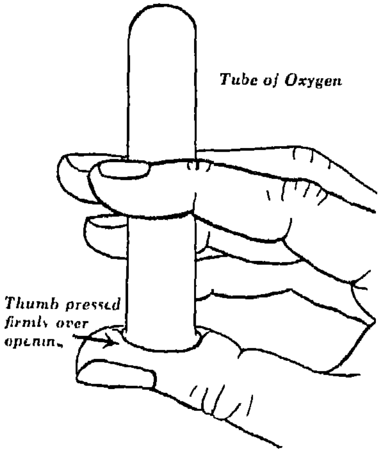
Why do Living Things need Oxygen?

You will remember in Unit 1 we talked about the way in which you took in air for breathing and you were told that living things need **oxygen** from the air for **providing energy.** Now we are going to try to find out something about this substance oxygen and how it is used by living things First we shall have to get some oxygen Oxygen is a colourless gas present in air mixed with other gases so it is not easy to collect it directly from air The best and quickest way to collect it is by heating a little **mercuric oxide,** a reddish powder, or **potassium chlorate,** a white powder, and collecting the bubbles of gas which they give off Only a very little oxygen dissolves in water, so you can collect the oxygen over water as shown in the diagram overleaf. Take a test tube with a tightly-fitting stopper Bore a hole in the stopper and put a piece of glass tubing, bent as shown in the diagram, just through the hole Now introduce your **mercuric oxide** or **potassium chlorate** into the tube and replace the stopper. Holding the tube by a paper holder, as shown in the diagram, allow the end of the tubing to pass into a vessel of water and point up into a small tube or jar filled with water If you have a proper pneumatic trough you need not hold the tube of water, but you can rest it on the bridge If you have not a trough use a basin and have someone to hold the jar of water with its base just submerged so that the water will not fall out. You are now ready to heat



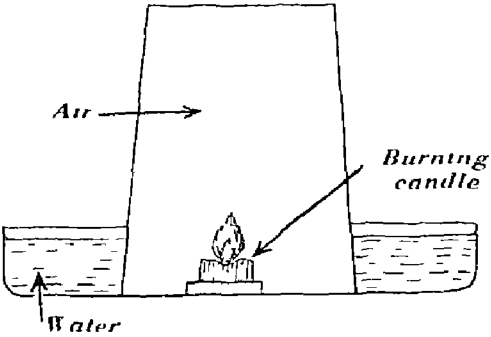
How to make Oxygen

Manganese dioxide or mercuric oxide is heated The bubbles of gas collected over water are oxygen the material in your tube This material, whether it is **mercuric oxide** or **potassium chlorate,** contains oxygen and heat causes it to part with this oxygen. As it is heated bubbles will run down into the tube The first bubbles will be bubbles of air which were in the tube and are being pushed out by the oxygen which is leaving the **potassium chlorate** or **mercuric oxide,** so you should let these escape But, after about half-a-dozen bubbles have escaped, you should let the rest run up into the water in the test tube. As they do this they will force the water down and soon you will have a tube full of a colourless gas. It looks like a jar full of air or what you call an "empty" jar Be careful when you are heating your tube to move the flame now and then, otherwise the glass will be heated in one part only and will crack. As soon as your tube in the basin is full place your thumb over the opening and move it out of the basin of water. Or, if it is a

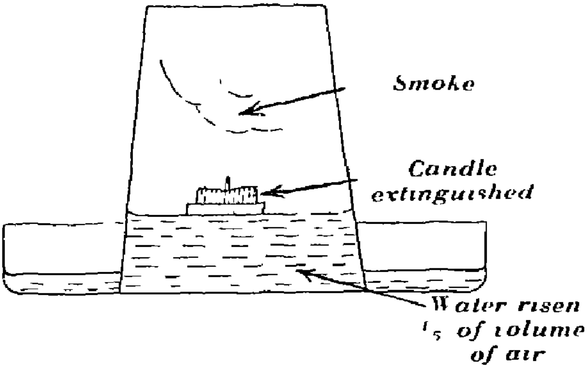

Tube of Oxygen
Thumb pressed firmly over opening

½ Nat size

Collecting oxygen



A candle will burn until it has used up all the oxygen which is available If it is in an enclosed space over water the water will rise up to take the place of the oxygen. About one-fifth of the air is oxygen and so the water rises to occupy about one-fifth of the volume of the air in the jar



hand against your mouth so that as much as possible of the air you are breathing out goes on to the lighted match. What happens?

How the Oxygen is used.

Now you have seen that breathing means the using up of oxygen, but we shall need to know a good deal before we really understand what breathing is for and exactly what happens when breathing takes place

You know, of course, that you are breathing all the time, even when you are asleep But you know also that if you have been very active you breathe much more quickly. If you want to run for some distance you take in a deep breath, don't you? And when you have been running or even walking very fast you find yourself panting when you have finished, or sometimes before you have finished, if you try to do too much. Panting is really a means of getting more air and so more oxygen And if you want to stay under the water for some time you take in a deep breath first, don't you? All these things suggest that if you are going to use up a lot of energy you need a lot of oxygen This is exactly what the oxygen you breathe does. It breaks up the foods into simpler substances and it releases energy in the body. You know a little bit about the way plants make their food with the aid of sunlight Well, some of the energy of the sunlight is locked up in the food the plant makes. If you have some plant-made starch or sugar (that is, any starch or sugar, for it is all made by plants), oxygen is able to break it down and release the energy which the plant had locked up in it That energy can be used by you for running or skipping or jumping. Or it can be used for keeping your body warm or for helping you to grow It is quite true to say that growing children need plenty of nutritious food Part of the reason is that growing uses up energy and the food you eat is partly changed to energy during the process. You remember, too, that people with a severe fever, even if only for a short time, lose weight very quickly This is because the body, being out of adjustment, is very hot and the heat is supplied by the action of oxygen in breaking down the foodstuffs The person in a high fever cannot eat any food and he is using his stored food for supplying this energy. So he loses weight very rapidly. When we breathe we take in air containing oxygen. This oxygen breaks down some of our food and releases energy The whole process is called respiration You will understand this word a little better later.

All Living Things Respire.

Every living thing respires in the same way. The living thing, whether it is a human, a bird, a white rabbit or a piece of grass, uses oxygen for breaking down some of its food and releasing the energy Now you should be able to answer this question. Would you expect very active living things, like yourselves or guinea pigs, to use more energy, and hence to require more oxygen, than less actively living things like shrubs and trees? And again, would you expect a living thing to use more oxygen when it was more active than when it was less active?

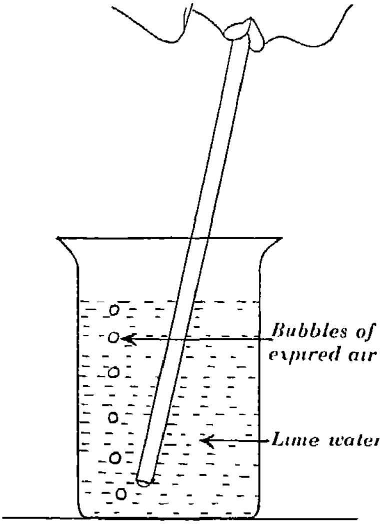
Now we should try to find out some simple way of testing whether a living thing is using oxygen Take a little clear limewater and leave it exposed to air. After a short time you will notice a slight cloudiness on the once clear limewater and a little later you will see flakes of a whitish substance on top. The **carbon dioxide** (another colourless gas) of the air turns limewater milky. Notice the name Carbon dioxide is formed when substances containing **carbon** are burned or joined with **oxygen.** This is what happens in respiration. The carbon of the sugar or starch, or whatever food particle is used, is joined to the oxygen to form **carbon dioxide** and this is liberated as a waste substance. Then the gases liberated from a body during respiration will contain carbon dioxide See if they do. Take another jar of clear limewater and breathe hard into it. The best way of getting expired air into the limewater quickly is to bubble it through a piece of glass tubing

Does the Limewater Turn Milky?

What about trying the same experiment with some other living things, such as frogs or snails We cannot easily persuade them to breathe into limewater, of course, but we can keep them under cover with a small jar of clear limewater for a short time and observe what happens to the limewater Of course, we shall not be able to keep them under cover indefinitely since we shall not be able to feed them easily Frogs like to feed on living, moving things like flies, and these would, themselves, be respiring Snails like green food, which is also living and respiring But frogs and snails will suffer no harm to be kept without food for two or three days

We shall have to take another precaution with our experiment, though. You remember a short time ago we exposed some limewater to the air in the room and it became milky, because the air contains a little carbon dioxide Now the air in which our animals are living will also contain a little carbon dioxide which will cause a cloudiness in the limewater. The only way we can find out how much of the cloudiness is caused by the carbon dioxide of the air and how much is caused by the animals will be to have another enclosed space just like that in which we have our frogs or snails and to put in this a similar container of limewater, but no animals. Then we can compare our two vessels of limewater and see whether we can come to any conclusion.

And now, what about plants? Plants are living things and need energy, too But since they are, mostly, far less active than active animals they do not need so much Some parts of plants, and plants in different stages, are more active than others

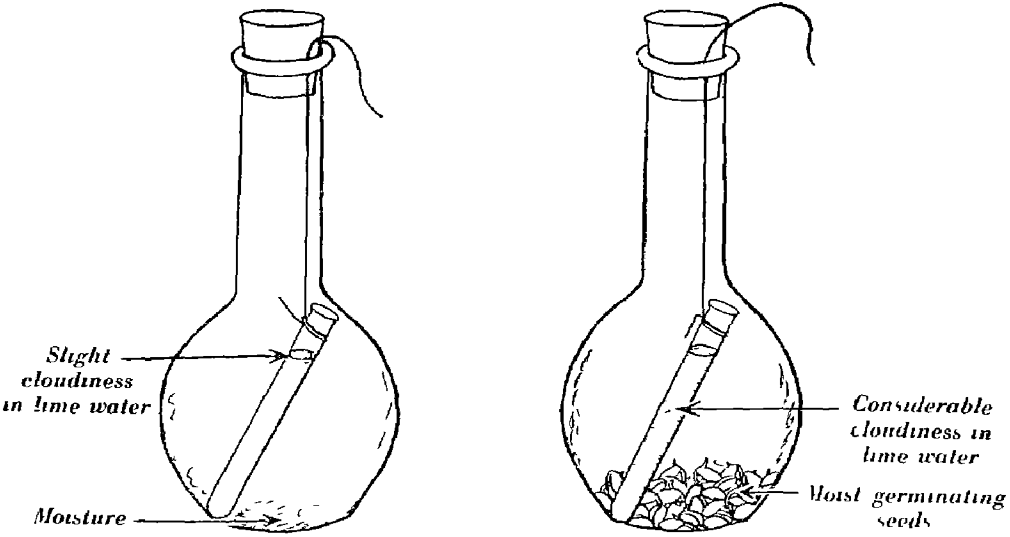


The carbon dioxide in expired air turns lime water milky

What would you suggest would be the best plant material for such an experiment? When you have decided, try it for yourselves and see whether plants use up oxygen and give out carbon dioxide while they are living actively

How is the Oxygen Obtained?

Up to the present we have been using two words —breathing and respiration, for the processes we have been describing. The word breathing only


Slight cloudiness in lime water
Moisture
Considerable cloudiness in lime water
Moist germinating seeds

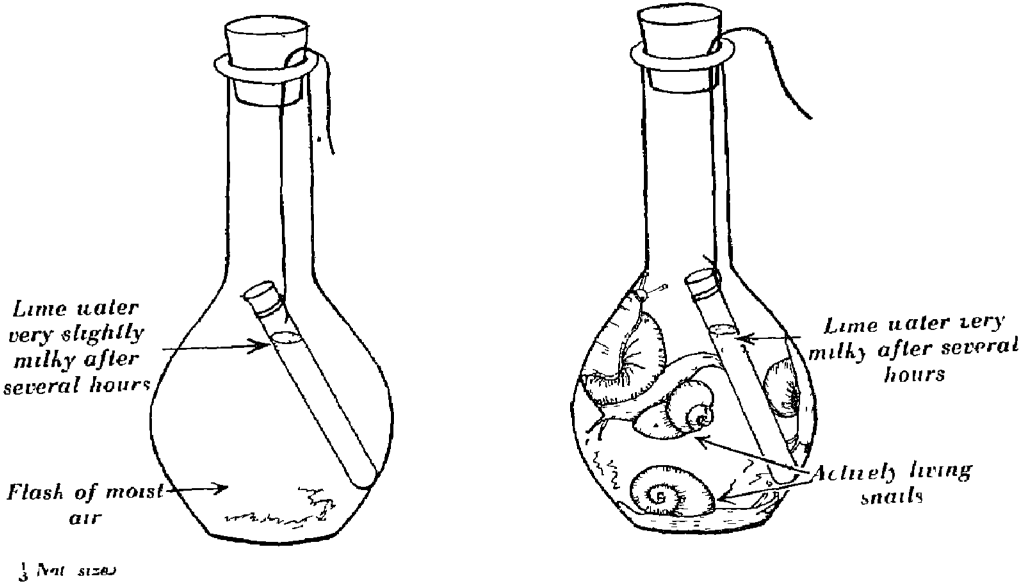
½ Nat size

Living things, like germinating seeds, give out carbon dioxide during respiration
This turns lime water milky

covers the taking in and giving out of air and we have seen that the most important thing is what happens to the air during the taking in and giving out. The best word for the whole process of the release of energy by means of oxygen is **respiration.** We say that all living things respire, that is, use oxygen for the purpose of releasing energy from food, and return, as one of the waste substances, carbon dioxide

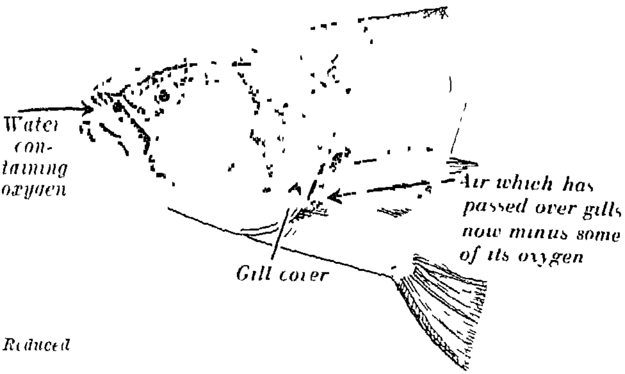
The principle of respiration, then, is similar in plants and in animals, but the means by which the oxygen is obtained and the carbon dioxide and other substances released may be very different. Let us look at a few different kinds of plants and animals and see how they do this Take large land animals like **ourselves** and **horses,** to begin with We take in a supply of air through our nostrils, mainly This passes through filters (which hold back some of the disease-bearing dust) into our breathing tubes and thence into our lungs In the lungs some of the oxygen is taken into the blood and from there to all the living cells of the body Notice the way you take in the air Standing with your head erect and lips closed (for you can get some air in through the mouth whence it passes to the lungs unfiltered) breathe deeply. Take special notice of your neighbour's action. See how he narrows his nostrils so that the air rushes in, as it does along a narrow passage, raises the lower part of his chest (this is done by means of a strong diaphragm) and expands. This enables his elastic lungs to expand. Now watch him pass out the air He inflates his nostrils a little and this helps to push the air out He allows his chest to fall, thus deflating it and allowing the elastic lungs to collapse and push out some of the air in them This goes on continuously, and so a constant supply of air passes through the body.

Now let us look at some animals which live in water


Lime water very slightly milky after several hours
Flask of moist air
⅓ Nat size
Lime water very milky after several hours
Actively living snails

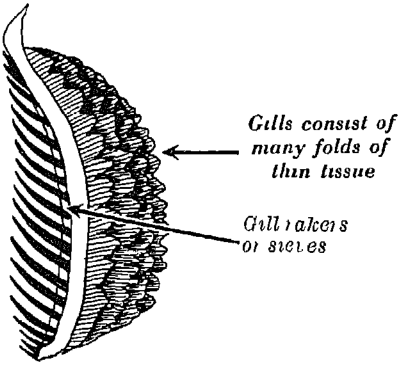
Living things, like snails, liberate carbon dioxide during respiration
This turns lime water milky

Watch fishes swimming round in the aquarium They live always in the water, never coming to the top to breathe. They must, then, get the oxygen which is dissolved in water. Notice how the fish keeps on opening his mouth and taking in water. Notice, too, the two gill flaps, one on each side of the body, and see how they constantly move in and out The fish constantly takes in water containing oxygen. This passes over the gills and out again So we need to have a look at the gills It is not easy to do this with a live fish without injuring it, but you can see them very well in a freshly killed one. Get a fish or a fish head with gills attached from the fishmonger and peer under the gill flaps There you will see the gills, several rows of very thin folded tissue You will notice that they are charged with blood vessels, giving the colourless gills quite a reddish appearance Why are the gills folded so neatly, do you think, and why do they have such a very extensive surface? The proximity of the blood vessels suggests that the oxygen is passed directly into the blood and carried all over the body just as it is in our own bodies


Water containing oxygen
Air which has passed over gills now minus some of its oxygen
Gill cover
Reduced

The fish is continually taking in water through the mouth This contains air which supplies the oxygen for the gills

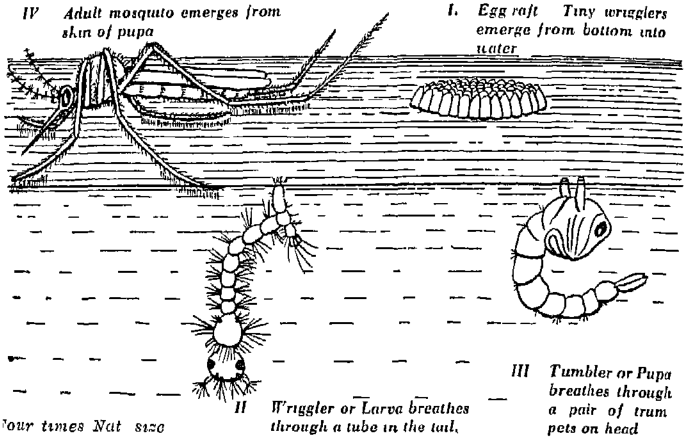
Have a look for some **mosquito wrigglers** in a tub of water (When you do find some destroy them when you have finished your examination of them.) Watch how they dart away as soon as you agitate the tub, or even when you cast a shadow over them But, after a very short time, they come up to the surface again. Take one out and look at it. What part is always pushed up out of the water? Obviously the **mosquito wriggler** is an air breather and has to get its air directly in this way. Can you understand why it is so easy to get rid of mosquitoes by putting a film of oil over the water in which they are living? **Tumblers,** the next stage of the mosquito, will probably be found in with the wrigglers, too You will soon see that they have the same habit of breathing as the **wrigglers** but they use a different part of their body What part do they use?



⅓ *Nat size*

Gills are able to take in large quantities of water which contains oxygen

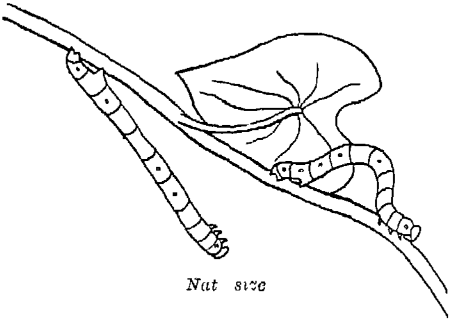
You have seen from your early experiments with the collection of oxygen that very little of it dissolves in water So, animals which depend entirely on the water for their oxygen supply, need to have large quantities of water passing over their gills all the time That is why, too, so many of the marine things live very close to the surface of the water where the constant movement of the waves drags quite considerable quantities of oxygen from the air into the water The surface waters near the seashore always have a


IV Adult mosquito emerges from skin of pupa
I. Egg raft Tiny wrigglers emerge from bottom into water
II Wriggler or Larva breathes through a tube in the tail.
III Tumbler or Pupa breathes through a pair of trumpets on head
our times Nat size

The mosquito is an air breather all its life In the early stages it lives in water but must come up to the surface for its air supply.

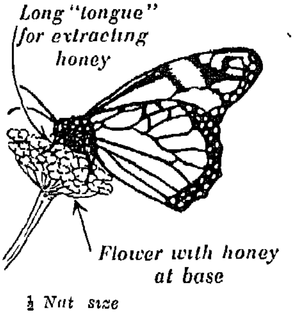
much better oxygen supply for this reason. And that is why the marine aquariums in the zoo have those fine bubbles of air passing into them all the time They are not bubbles of oxygen, but air, which, as you know, contains oxygen, and so the water in the aquarium is assured of a constant supply to keep the animal life going. The reason why we do not usually need to pump air into a fresh water aquarium we shall have to leave until a little later.

Now find a **caterpillar** (a smooth one for preference) and see if you can find out how it gets its air. It is



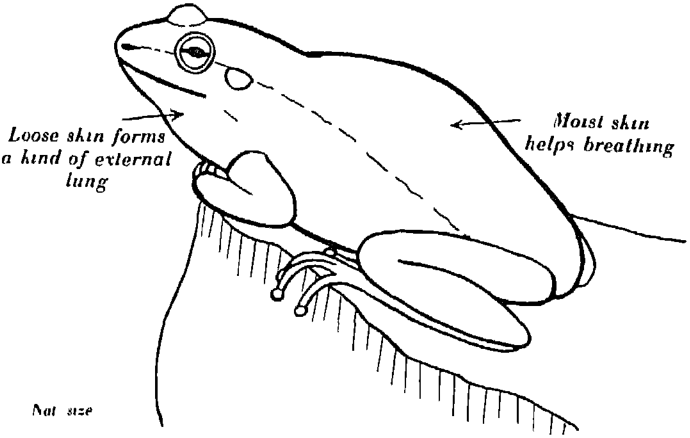
A smooth caterpillar Note the openings along the side of the body through which the air passes

not so very fast in movement so it will not want a very great deal. See the tiny holes on the sides of the body—two on almost every segment, one on each side One or two of the segments near the head are usually without them. These are breathing holes. They open up into tubes which wind through the whole of the body and create an air-carrying system There is no blood. The animal is able to regulate the supply of air to some extent because there are muscles allowing the breathing pores to open and close and so alter the direction of the air current from time to time The opening and closing is automatic, like our


Long "tongue" for extracting honey
Flower with honey at base
½ Nat size

As the butterfly moves a current of air passes down the veins of the wing and into the body breathing movements If now you take the adult of the caterpillar, a **butterfly** or **moth,** you will see an extension of the same system in the veins of the wings which, while decorative, also serve the useful purpose of passing air along their narrow passages into the entire body of the **butterfly** or **moth** which is, as you may guess, served in the same way as it was when it was in its earlier stage of caterpillar.

Now we know something about the way complex land animals, simpler land animals and water animals

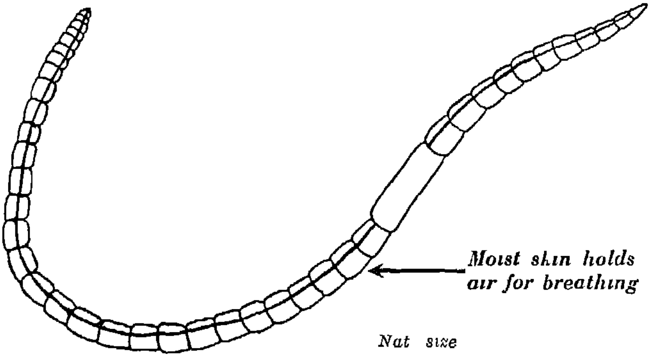

Loose skin forms a kind of external lung
Moist skin helps breathing
Nat size

The frog is not perfectly adapted to land Its moist skin takes in air, and the loose flap of tissue under the head helps its imperfect lungs, too

get their air for breathing, let us have a look at the way some of those animals which are partly land and partly water animals get theirs. Take a **frog** to begin with. Watch it as it breathes It looks somewhat like a caricature of a human with his breathing mechanism exaggerated

See how the skin just under the head moves up and down The **frog** has a pair of lungs, but it has no diaphragm to help the entry of air and no ribs to keep the chest rigid, as we have. When the frog drops that flap of tissue the air is being sucked out of the lungs. When it raises it air is being pushed into the lungs Notice, too, the frog's moist skin, which takes in oxygen from the air and so helps to keep the animal continuously supplied.

Earthworms are other animals which can only live in moist places. For the most part they move slowly and so will not need so much oxygen But they do need some and they need a constant supply Examine several **earthworms** at different times and from different places. Each time you will notice that the worm is moist. This continually moist skin is sufficient to keep a supply of oxygen from the soil passing into the body of the worm for respiration You remember, don't you, that after there have been several days of continual rain earthworms begin to creep out of their burrows on to the top of the soil, or even on to our paths, where they are liable to meet disaster Now, if you think for a moment and


Moist skin holds air for breathing
Nat size

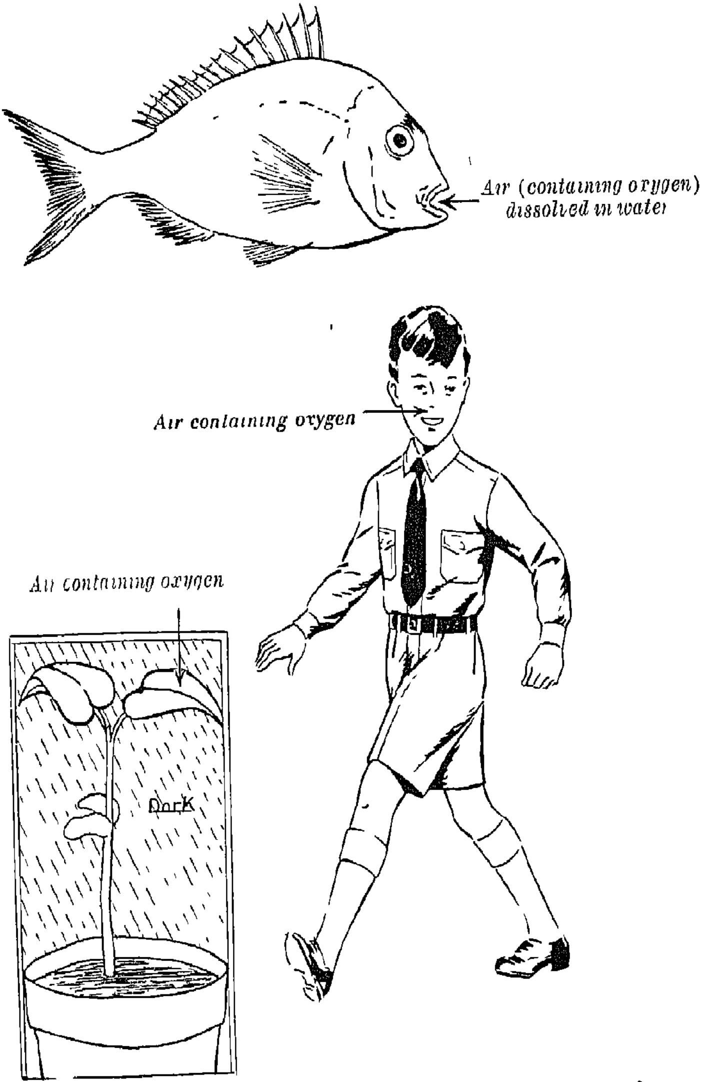
The moist skin of the **earthworm** is continually taking in air containing oxygen remember that **earthworms** do not need much oxygen but that they do need some, you will be able to explain why earthworms come up to the surface on such occasions.

Summary

Now all these things you have been learning will have shown you two important facts.—

1 Every living thing needs **oxygen for respiration.** This oxygen is responsible for breaking down the food of the living thing and liberating some of the stored energy of the sun which it contained

2. Every individual unit of the living thing must have **oxygen for respiration.** If the body is a simple one the oxygen can easily get to all the parts. But when the body is more complicated, like our own, there must be some special means by which the oxygen is carried to all the living parts The oxygen is carried in the blood stream. The air which contains oxygen passes into the lungs The lungs have lots of tiny blood vessels serving them and these tiny blood vessels become filled with blood charged with dissolved oxygen from the lungs. These tiny vessels unite to form larger ones and, by the aid of the heart which pumps the blood round the body, the vessels are able to carry it to all the living cells As it passes through the living cells the oxygen is taken out of the blood and, finally, it reaches the lungs again to receive another supply of air This is going on all the time in our bodies. Air passes in through our nasal passages, down the bronchial tubes into the lungs Here some of the oxygen is dissolved and passes into the blood vessels, and the rest of the air, with an additional amount of carbon dioxide obtained from the breaking down of the food during respiration, is passed out to the air The oxygen-charged blood



All living things use oxygen but they have different means of obtaining it

Plants which grow in very boggy places have difficulty in getting enough air for their roots One species of Mangrove sends up these fine, spongy finger-like projections to gather air for passing to the roots

travels round the body, parting with its oxygen as it reaches living cells which need it and receiving **carbon dioxide** from them as they break down their food supply In the lungs again the carbon dioxide is released and the blood gets a fresh supply of oxygen.

UNIT 5

How do Plants and Animals get their food?

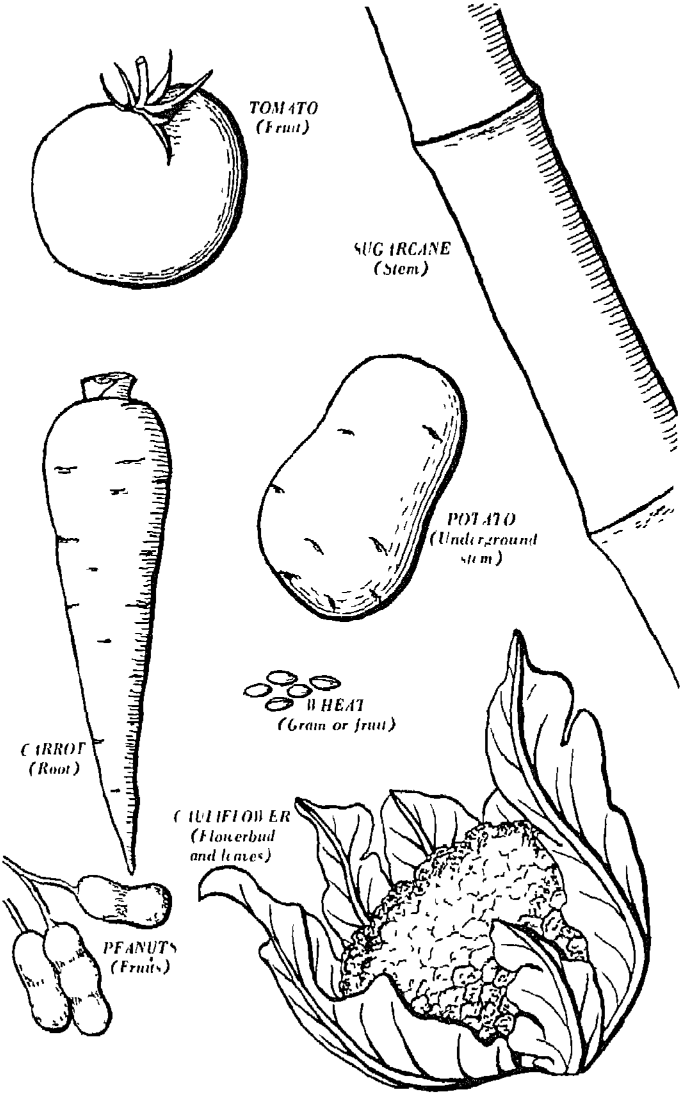
We know now how plants and animals get their air for respiration and that this results in the production of energy which enables the living thing to be active. The energy, you will remember, was locked up in the food of the plant or animal. Now we have to find out something about the way in which plants and animals get their food.

Let us first have a look at the way in which plants live and get their food.

How Plants get their Food.

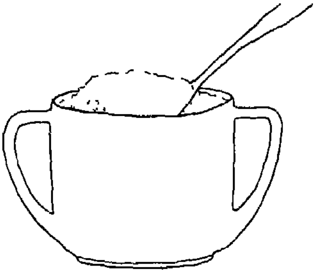
Let us look first of all at the plant products which we use as food to see what we can find out about them We eat vegetables like potatoes, carrots, pumpkin, fruits and seeds like oranges, apples, melons, brazil nuts, and so on Sometimes we eat the root (carrots, parsnips), sometimes the fleshy stem (potato, celery), sometimes the flower bud (cauliflower), sometimes the fruit (tomato, melon), sometimes the seed (peanut), sometimes we eat the material extracted from some part of a plant like the sugar from the stem of the sugar cane, the flour from the grain of the wheat, and so on.

There are two main kinds of plant products—**sugar** and **flour**. Remember all the uncooked plant foods you have eaten which have tasted sweet—ripe fruits of orange, watermelon, mango—young peas and sweet

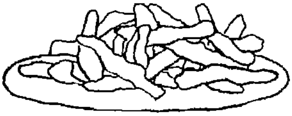


Some plant products which we use as food corn—ripe tomatoes, and many others Sugar is easily detected in plant products because it is so easy to taste.

Flour, you have just discovered, is another kind of plant product. You get **flour** from maize, wheat, rice, potatoes, and you know, too, that many other foods like the cereals—your rolled oats or wheatmeal, your crispies or wheat biscuits are floury or starchy foods. I want you to try one or two simple little experiments with this **flour** or **starch.** Take a few grains of **starch** from any source you like, from the packet in the laundry or from the porridge bin or the flour tin Be sure you have not just been eating some sweet things just beforehand. Now roll a tiny bit round on your tongue (where the taste buds are) and taste it very carefully Does it seem a little bit sweet to you after a time? It usually does, because **starch** and



Sugar is one important plant food

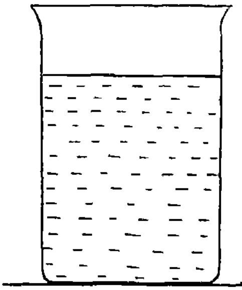


Starch is another important plant food

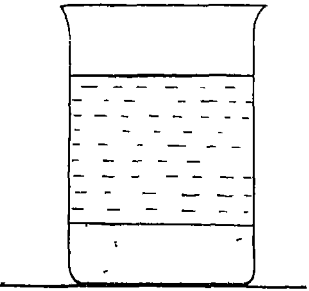
Some plant products

sugar are very closely related substances, and starch is changed into sugar by the digestive juice in the saliva of the mouth.

Here is the next simple experiment Take another little portion of **starch** from the same source and put a drop of household iodine on it Notice carefully what happens Try the same experiments on the freshly-cut surface of potato, on a broken maize or wheat grain, on a piece of oatmeal, on some cornflour



Sugar dissolves in water



Starch settles at the bottom and does not dissolve in water

and on any other floury or starchy foods Coloured starchy substances like pumpkin or carrot will not give you a very satisfactory result because their colour conceals it.

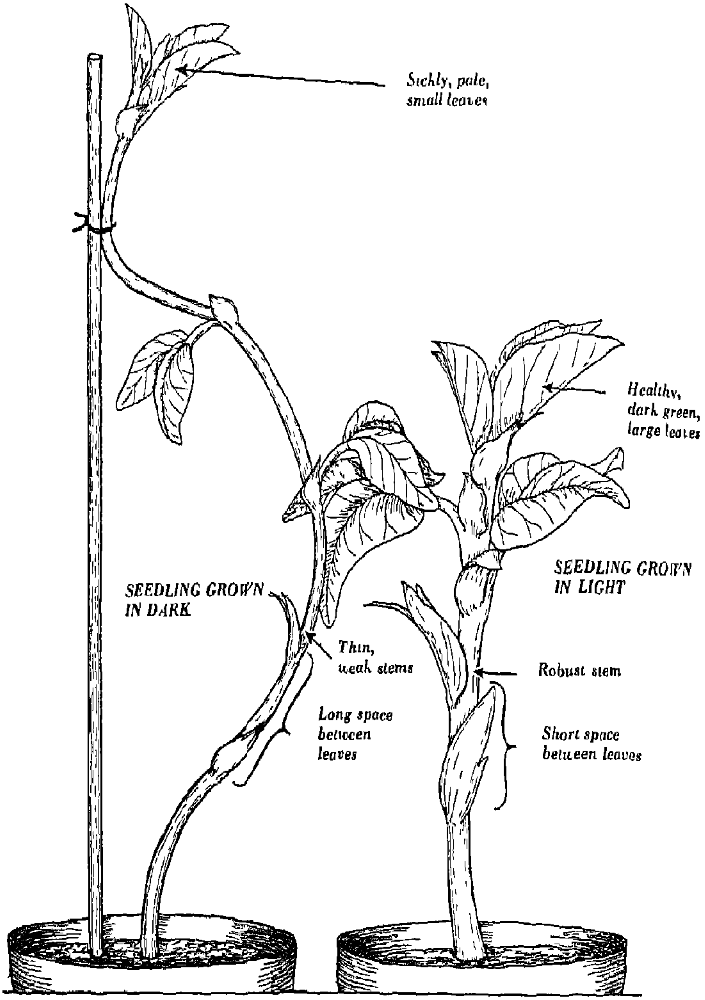
So you discovered that these starchy substances turn purple when iodine is added to them This is very useful, for no other substance that we know of does this. So that if a substance gives a purple or bluish colour when iodine is put on it there is starch present.

Take a little **sugar** and stir it up vigorously. What happens to the **sugar**? Repeat the operation with **starch.** Describe the difference between the action of the two substances Notice, too, what happens to the stirred **starch** after a short time

Starches and **sugars**, then, are substances commonly produced by plants. Is there anything else we know that is essential to the healthy growth of a plant? Take a box and place it open side down over some grass or some other soft plants Don't let the box lie flat on top of the grass, but place it so that it cuts off the light without pressing and so injuring the grass in this way. In three or four days have a look at what has happened The grass has gone quite yellow, hasn't it? So that if light is not available the plant cannot develop that green colour which is so common in plants. Put the box back over the grass again and continue watching from day to day. You will find that the grass soon begins to die. Grow some seeds completely in the dark and some others in the light Those in the dark will begin to grow quite well, just as well as those in the light, and, then, after a time, you will see a very big difference in your two sets of seedlings Those which were grown in the light will be sturdy and green in colour. Those that were grown in the dark will be thin and weak and there will be no green colour in them at all Light is necessary, then, for the production of the green colouring matter in plants Without it they soon wilt and die

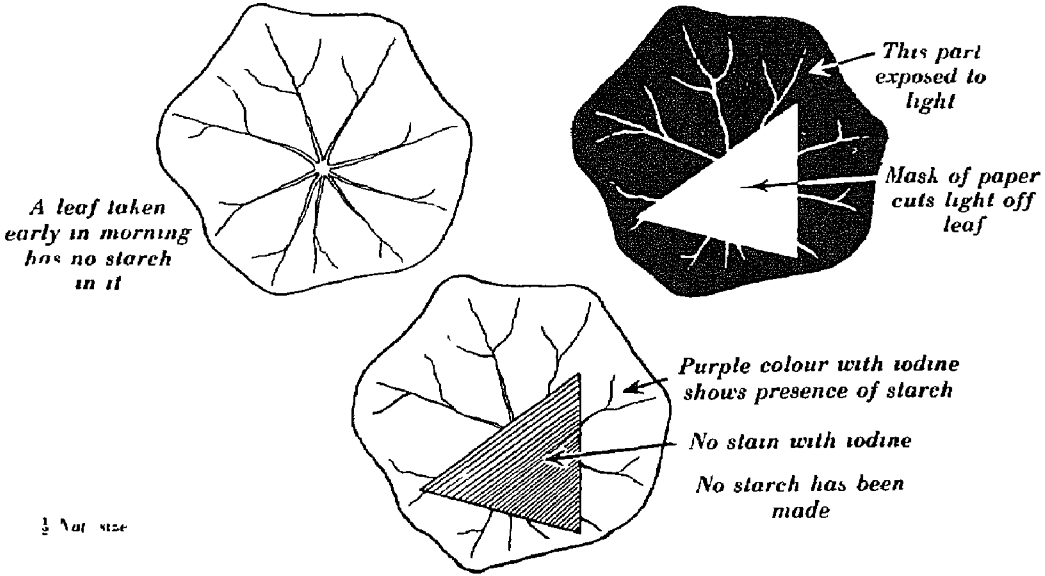
Are Green parts of Plants Concerned in Food-making?

Perhaps we could find out now whether green parts of plants which have been growing in the light for some time have any **starch** or **sugar** in them. Let us decide, first of all, whether it would be easier to show the presence of **sugar** or the presence of **starch.** **Sugar** dissolves in water, as you have found out, so it will not do to try to test for **sugar** if we need to use water, because the **sugar** will dissolve in the


Sickly, pale, small leaves
Healthy, dark green, large leaves
SEEDLING GROWN IN DARK
SEEDLING GROWN IN LIGHT
Thin, weak stems
Robust stem
Long space between leaves
Short space between leaves
Nat size

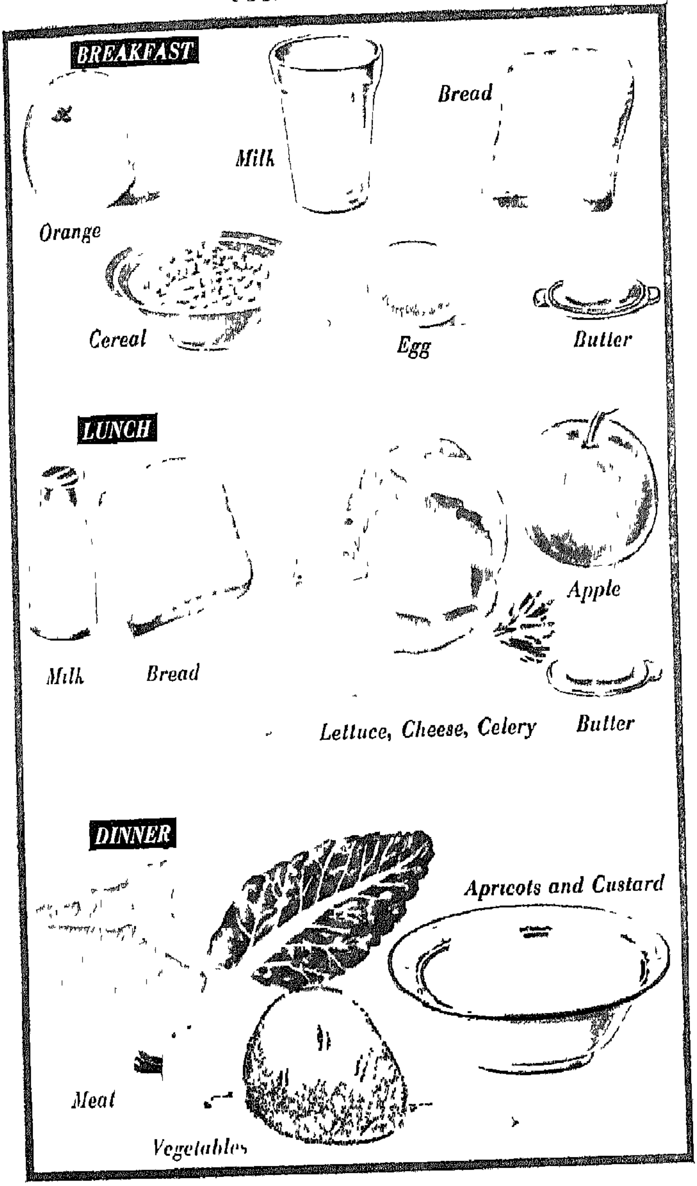
Plants in Light and Darkness.

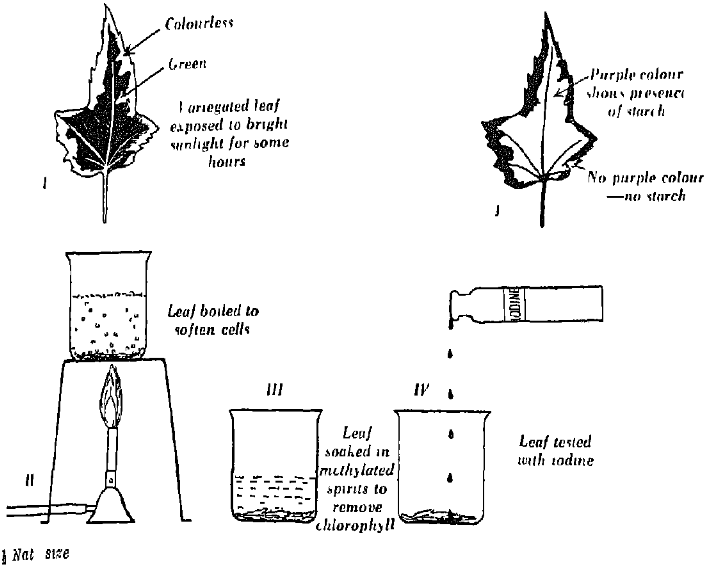
water. **Starch** does not dissolve in water, as you found out also Besides this, **starch** gives a very good colour reaction to iodine, so that if we think either or both substances may be present it would be better to test for **starch** first Let us make sure that our plant has had its green coloured parts exposed to the light for some hours (It is best to do this experiment some time between about 11 a m and 3 p m and during the summer months You will discover why later) A soft-leafed plant like **Nasturtium** or **Geranium** serves the purpose very well Take one of the leaves which has been exposed to the bright light for some hours. How shall we find out whether it contains starch? First try this Pour a little iodine on the leaf Then shake the leaf vigorously. The iodine will roll off You will remember having seen drops of water rolling about on **Nasturtium** leaves after rain has fallen. A waxy covering over the leaf prevents liquids from entering So, if the **starch** is inside the leaf you will have to find some way of allowing the iodine to penetrate Boiling in water will do this This would also remove any **sugar,** wouldn't it? So that it would be no good testing for **sugar** this way When your leaf has boiled for a few minutes you will notice that it is very wet and that any liquid substance will easily be able to penetrate. But you will still not be able to test for **starch.** The leaf is a green colour and so, even if there were **starch** present, the purple colour would not easily be seen. We need to find some way of getting rid of the green colouring matter. If you look carefully at the water in which the leaf has been boiling you will notice that it is slightly green in colour, indicating that some of the green colouring matter has come out But if you tried to get it all out this way you would have to boil your leaf for so long that it would tear to pieces and you could not test it easily But **methylated spirits** dissolves green colouring mat-


This part exposed to light
Mask of paper cuts light off leaf
A leaf taken early in morning has no starch in it
Purple colour with iodine shows presence of starch
No stain with iodine
No starch has been made
½ Nat size

The green parts of the plant act as a factory In the presence of light starch is manufactured Its presence may be shown by the iodine test

FOOD FOR A DAY



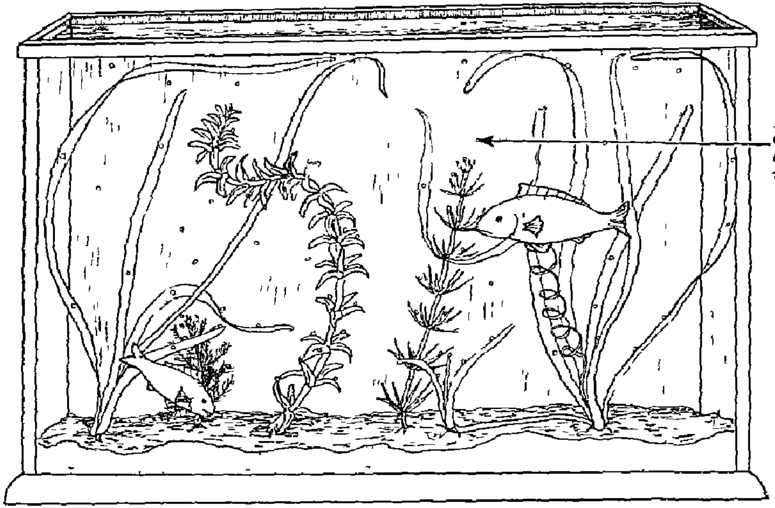

Colourless
Green
Variegated leaf exposed to bright sunlight for some hours
I
Purple colour shows presence of starch
No purple colour —no starch
V
Leaf boiled to soften cells
II
III
IV
IODINE
Leaf soaked in methylated spirits to remove chlorophyll
Leaf tested with iodine
½ Nat size

Green colouring matter is necessary for the manufacture of starch. In the non-green part of the leaf no starch is made

ter of plants. Now that you have softened the leaf so that liquids can penetrate you may pour off the water and cover the leaf with methylated spirits. Put a cover over the vessel containing the leaf and methylated spirits, for this evaporates very quickly. In about a day you will find that the methylated spirits has become a lovely, rich green and the leaf is quite yellow All the green colouring matter has gone out of the leaves into the methylated spirits

Now wash your leaf thoroughly to get rid of the methylated spirits clinging to it Notice how brittle the leaf has become.

The leaf is now quite yellow and liquid can penetrate it, so it is ready to be tested for **starch.**


Bubbles of gas (containing oxygen) coming from plants in sunlight

½ *Nat size*

The tiny **bubbles** given off by the plants in bright sunlight contain **oxygen.** Some of this oxygen will dissolve in the water and may be used by the animals who are able to live entirely in water like fish

Put it in a saucer and pour a little iodine over it. Leave it there for a few minutes Then pour off the iodine, wash the leaf and spread it out on a piece of white paper Is there any **starch** there?

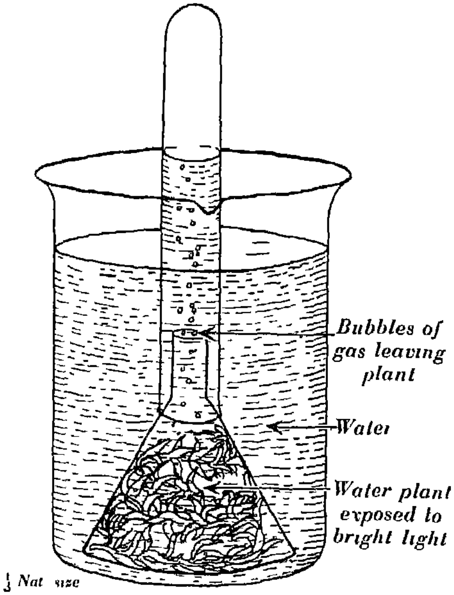
The leaf which you have just been testing was a green one which had been exposed to light for several hours. See whether you could invent experiments to find out the answers to the following questions:—

Is light necessary for starch-making in plants?

Is green colouring matter necessary for starch-making in plants?

What Gas do Plants give off in Bright Light?

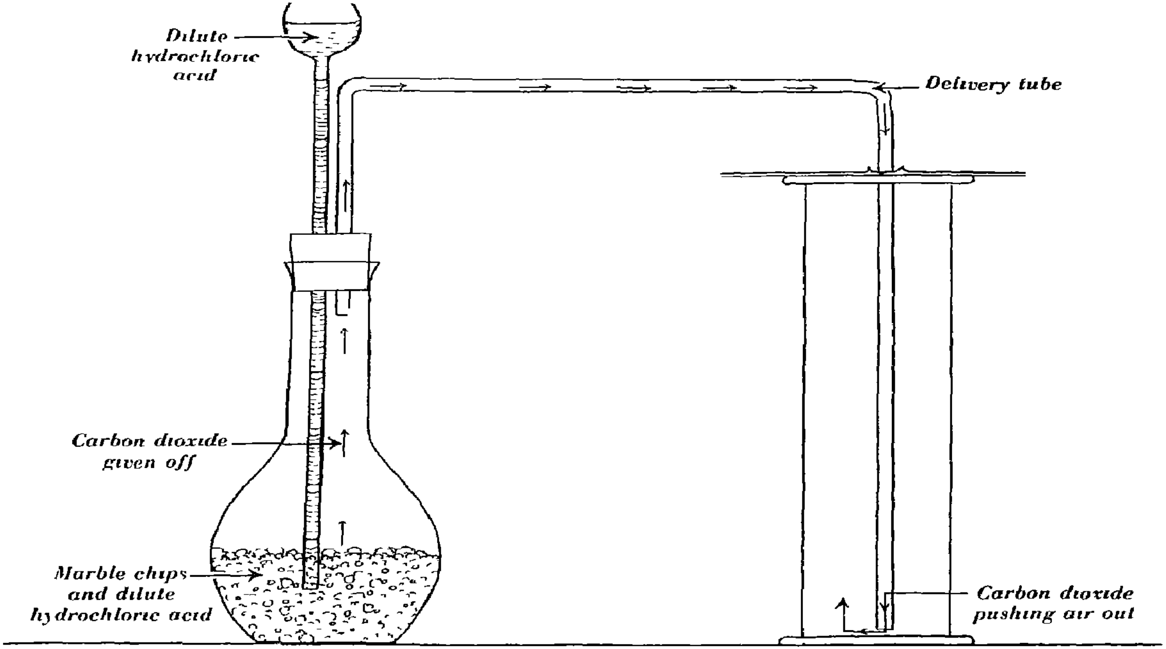
The next part of our work requires an aquarium or an outdoor pool in which water plants are growing vigorously If you watch the plants carefully you will notice that tiny bubbles of a colourless gas are constantly coming off those parts of the plant on which the light is shining Let us collect some of these bubbles and see what gas it is Take a little funnel and place it in the aquarium to hold down some of the plants Be careful not to injure the plants as you do this because you want to study actively living plants See that the end of the funnel is well under the water Now take a small test-tube, fill it with water and, with your thumb firmly held over the opening so that the water cannot escape, place it over the funnel, removing your thumb only when the mouth of the tube is under the water You will now have your tube of water resting on the funnel over the plant and the bubbles of gas which escape from the plant will rise into the tube, pushing the water out as it does so Be sure to commence your experiment in the morning and arrange to have the sun streaming down on your plant for as long as possible After some time (this may be one day or you may


Bubbles of gas leaving plant
Water
Water plant exposed to bright light
⅓ Nat size

By the method shown here the gas given off by a plant in bright sunlight may be collected Tested with a glowing splint it is shown to contain a great deal of **oxygen**, for the splint will be rekindled

have to wait several days) you will have a test-tube full of a colourless gas. Remove the tube, preventing the gas from escaping by placing your thumb over the opening **before you lift it out of the water.** Test it with a glowing splint like you did when you had a test tube full of oxygen You will find that your splint bursts into flame. It is not actually a tube of **oxygen** that you have, but a tube of air containing a great deal more **oxygen** than ordinary atmospheric air contains.

So you see plants liberate **oxygen** in bright sunlight But you have already shown that plants use **oxygen**


Dilute hydrochloric acid
Delivery tube
Carbon dioxide given off
Marble chips and dilute hydrochloric acid
Carbon dioxide pushing air out

When dilute **hydrochloric acid** is poured on marble chips a gas, **carbon dioxide,** is given off
Since this is a heavy gas it will push air out of a jar

and liberate carbon dioxide during respiration You will remember, though, that when we carried out our experiment on respiration in plants we did one of two things—we either used parts of plants that were not green or we put our plants away from the light In the light, then, the manufacture of food in the plant results in the liberation of oxygen

Do Plants use Carbon Dioxide?

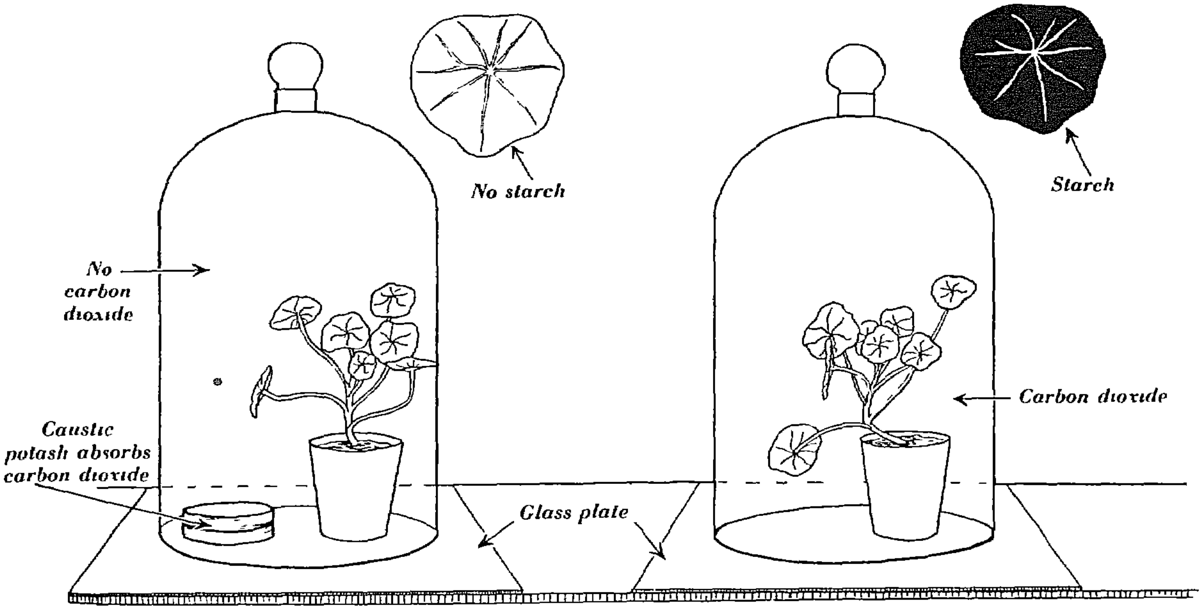
There is another point to be settled What happens to the carbon dioxide which is liberated by plants during respiration when they are in the bright sunlight? Because leaves are alive they must be respiring We need to know something about this substance **carbon dioxide,** don't we? We do know something already We know that it turns limewater milky Let us make some and examine it It is a colourless gas present in air We can make it by pouring **dilute hydrochloric acid** on any form of **limestone,** on pieces of marble or on eggshell It is very soluble in water, so we cannot collect it over water as we can oxygen, which is only slightly soluble in water But it is a heavy gas and if we let it flow into a jar it will push out the air which already fills the jar So set up an apparatus as shown in the diagram, allowing the delivery tube to pass down into a vessel of air When you think the jar is full (you can't tell yet because air and carbon dioxide are both colourless gases), put a cover of some kind over the jar. You will have to guess when the jar is full by the rate at which the bubbles have been coming through the tube Now, let us test our gas. But before we do let us put another jar under the delivery tube and collect some more of our carbon dioxide Now for the test. Let us see just how milky this gas turns limewater. Put a few drops of limewater into the jar and shake it up vigorously. Now breathe into a jar of clear limewater yourself through a piece of glass tubing Compare the results

When you have a second vessel of carbon dioxide try another test. If carbon dioxide is given off from plants during respiration or during burning it should extinguish a flame So plunge a lighted match down into the jar Does it go out? (If you want to collect carbon dioxide again this is one way of finding out whether the jar is full.)

Now you know something about this gas, **carbon dioxide.** There cannot be much, if any, liberated by plants in bright light But all living things respire and, in so doing, liberate **carbon dioxide**

This **carbon dioxide** is then probably used up by the plants when they are making their food Let us see if we can find out whether this is so We could determine this by finding out whether plants were able to make any starch at all, if there was no **carbon dioxide** present Of course, we will need to have starch-free plants to begin with Let us take two healthy, potted plants If we put both plants away in the dark they will not make any starch, as we have also seen. So let us do this. After our plant has been in the dark for about 24 hours let us take it out and test one of the leaves from each plant to see if there is any starch in it. (While we are doing this we must leave our plant in the dark, otherwise the other leaves will get busy making starch, won't they?) First, we shall boil the leaves to soften them so that liquid can penetrate Then we shall soak them in methylated spirits till all the green colouring matter has come out, wash them, and test them for starch with iodine If we get no purple colour there is no starch there Now, if one leaf from our plant had no starch it is fairly certain that the other leaves are starch-free, too.

We need to know how to arrange things so that our



Much reduced Plants cannot make starch unless they have a supply of carbon dioxide If all the other factors are present but there is no carbon dioxide there will be no starch plant can get no **carbon dioxide.** A substance called **caustic potash** absorbs **carbon dioxide** from the air Take a small piece of it (be careful not to touch it with your fingers; caustic means burning), and put it on a saucer. Now put a glass over it. After a few minutes, when the caustic potash has had time to absorb the carbon dioxide, lift the tumbler and quickly insert a little jar of clear limewater. Replace the cover as soon as you can, so that you do not let in much of the outside air. At the same time set up another similar piece of apparatus, but leave the caustic potash out This one will have carbon dioxide from the air in it After about 24 hours examine the **limewater** from both vessels If the caustic potash has removed the carbon dioxide the limewater from that vessel should still be clear. Is it?

If you are satisfied that the **caustic potash** will take all the **carbon dioxide** out of the air you can then set up another experiment like the one you have just completed, but this time you will include the starch-free plants. You will need two large glass bell-jars to fit over the plants and two glass or smooth wooden plates on which these will stand. Place them where they will get plenty of light Under one bell-jar put a vessel of **caustic potash** and, after a few hours, put a vessel of clear **limewater** under both of them. When you are satisfied, by the appearance of the **limewater,** that the bell-jar with **caustic potash** has no **carbon dioxide** in it and that the other one has, place your two plants which have been kept away from the light, one under each bell-jar Get some soft paraffin wax and attach the bell-jar to the plate so that no outside air can get in Leave them both exposed to the bright sunlight for four or five hours Now remove one leaf from each plant and test them for starch. What do you find?

How Plants Work in the Light.

Now you know something about the way plants work in the sunshine They use up **carbon dioxide** for food-making and liberate **oxygen.** At the same time all the living cells are respiring and using up oxygen and liberating carbon dioxide But the rate of respiration is slow and only a little oxygen is used and the rate of food-making is much faster and supplies all the oxygen for respiration. There is still some oxygen left over and liberated from the plant. But, of course, away from the light there is no food-making going on and so carbon dioxide is liberated In the light the carbon dioxide that would otherwise be liberated is used up for food-making, of the oxygen liberated during food-making a little is used up for respiration and the rest leaves the plant So, if you test the gas which leaves the plant in bright sunlight you will find it is rich in **oxygen,** while the gas which leaves it when it is in the dark is rich in **carbon dioxide.**

Setting up an Aquarium.

We know enough now to set up an aquarium and there is a great deal to be learned from observing the plants and animals that live there We may have a vessel made wholly of glass if we like That is the best type for observation though it is not necessary to the health of the inmates. As long as enough light enters to allow the plants to make their food that will be sufficient. Our aquarium needs a good surface exposed to the air for most purposes. In the bottom of the aquarium we need some soil or sand to hold the roots of our plants. Sand will not cause the water in the aquarium to become cloudy like soil will and most water plants find it sufficient. When we have made a smooth surface on the sand we can plant some clean water plants, well-spaced to allow for growth and not too close to the walls They should be rooted firmly A good way is to tie a pebble on the root and embed this, for the sand does not hold the roots very firmly while the water is being poured over Our plants should be gently washed under a tap before planting, because quite often they carry diseases which may spread to other living things in the aquarium We are now ready to pour in the water Taking a piece of stiff paper we lay it gently over the tops of our plants and then pour or run the water in gently The object of the paper is to prevent the running water from disturbing the bottom. When we have sufficient water to fill the aquarium we remove the paper, which is now floating on the top. If the water is a little cloudy it will clear in a day or two You need to remember one thing—when the plants are freshly placed in an aquarium they will not be living very actively They will be respiring, for all living things must respire all the time But they will not be making any food, because they must first establish themselves in their new home For food-making they use water which they take in through their roots and these roots must first become properly established. That means that they will not be liberating any oxygen It would not be wise, then, to put any animals into the aquarium for a few days This is because the animals depend for their oxygen for breathing on that liberated by the plants during food-making plus the small amount which the water absorbs from the air. You should not put any animals into the aquarium until the plants show some sign of activity. As soon as new shoots begin to appear you will know that the plant has established itself and you can go ahead Probably you will want to put some fish in Now fish are active creatures and need a good deal of oxygen, so you must be careful not to put too many in your jar. A good rule to follow is to allow one inch of fish to every gallon of water. This would be about two small goldfish in an aquarium measuring 10 inches by 10 inches by 15 inches.

Once your inmates have settled you can, if you wish, put a glass cover over the aquarium. If you have a good growth of plants and not more fish than I have suggested, there will be quite enough oxygen to supply the fish with all they want and you need not depend on the air to supplement this The cover also prevents evaporation and makes it unnecessary to be continually adding more water

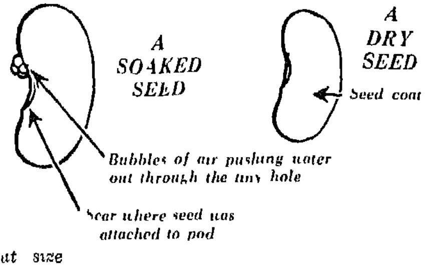
Plant and Animal Food.

Now let us have a look at the way some animals get their food Let us take ourselves to begin with We can start with breakfast. For breakfast I had an orange which came from a plant, a cereal (wheat-meal), which came from a plant, with sugar from a plant, milk from a cow which lived on plants, wheat-meal bread made from the flour of a plant, butter from a grass-eating cow. Then I had an egg from a hen which was fed on plant food For lunch I had bread, celery from a plant, butter and cheese and milk from a cow which lived on plant food, and an apple from a tree. For dinner I had meat from a grass-eating sheep, vegetables from plants, stewed apricots which had grown on a tree, with custard made with milk from a cow and egg from a hen. And so it goes on All my food comes directly or indirectly from plants.

Just think of some of the animals which you studied in the section on respiration and find out what their food is. Take the earthworm, the frog, butterflies and moths, caterpillars, mosquito wrigglers and tumblers Find out what their food is Make a list of them all under the heading **plant food** and **animal food.** Then take each form of animal food and find out where it gets its food You will find out that even animals which eat other animals for food are ultimately dependent on plants for food

ALL ANIMALS ARE DEPENDENT
ON PLANTS FOR THEIR FOOD.

squeeze the seed very hard and you will probably notice a drop of moisture oozing out of a tiny hole at one end of the scar. This a very important hole, as you will see Peel off the outside coat If you have a soaked seed see how swollen the seed has become, pushing the coat with it and smoothing out all the wrinkles that the seed had when it was lying in the packet See what a good protection the coat is When



A SOAKED SEED
A DRY SEED
Seed coat
Bubbles of air pushing water out through the tiny hole
Scar where seed was attached to pod
Nat size

The seed takes in moisture and begins to swell

you have peeled it off take a peep inside Look particularly to the spot just under that tiny hole you discovered. Do you see a neat little pocket?

Look at the uncovered seed See the little shoot-like structure that you have just pulled out of the pocket. See how well it fitted and notice that it was pointing towards that wee hole. See the fat, white fleshy things that take up most of the space. Now open up the two fleshy things and peep inside. They come apart very easily, don't they? Look closely at the end where the little outside shoot came from. There you will see another little shoot tucked away But this one has very wee leaves on it as you can see clearly, even without a magnifying glass It is very carefully protected in between the two fat "seed leaves" as we call them

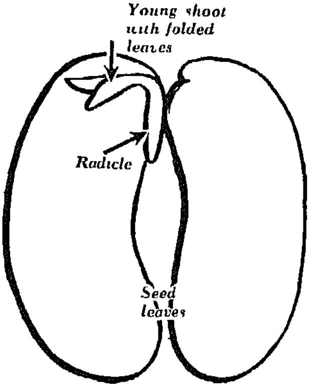
Plants produce new plants like themselves
See the little Wattle seedling on the slope

Now you know that the part inside makes up the young plant You have seen that it consists of three parts:

(a) An outside smooth, white shoot

(b) An inside folded shoot.

(c) Two fat seed-leaves.



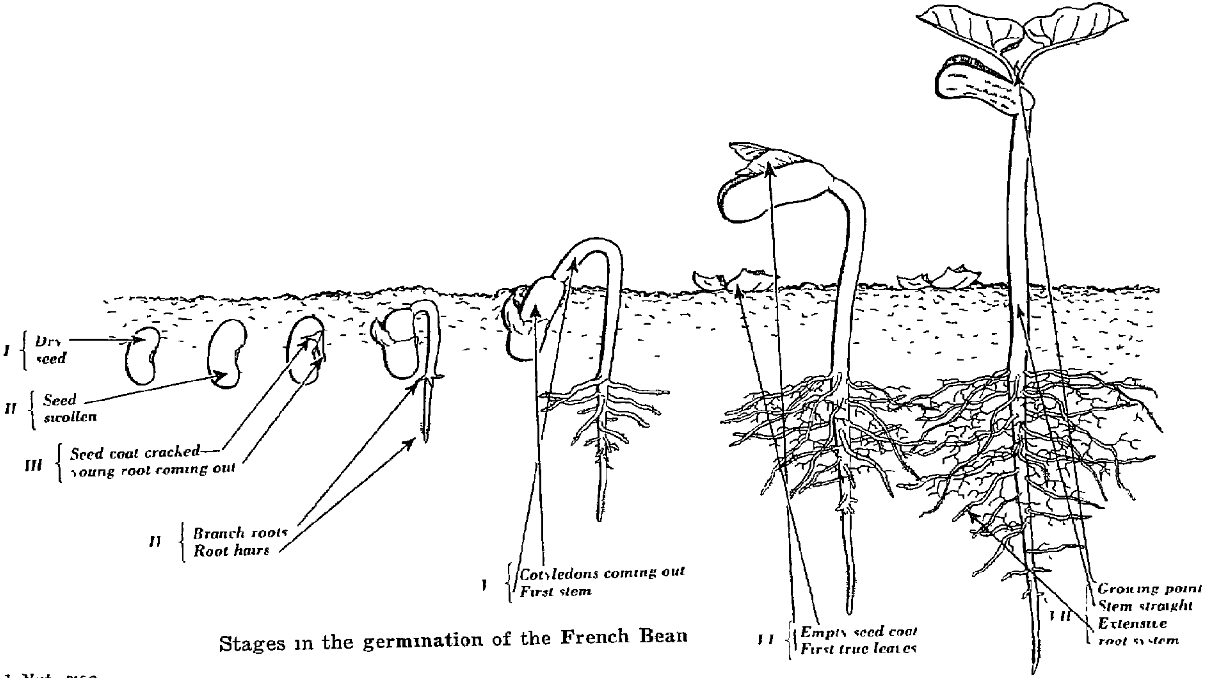
Twice Nat size

The seed contains an entire baby plant — young shoot, young root (radicle) and stored food in the seed leaves

Let us take some more seeds and plant them to find out just how the young plant gets out. You noticed when you soaked the seeds that they became very much larger because they took up water and swelled So we need to provide our young plants with moisture We know also that things grow better with warmth, so we should grow them in a warm place. We know, too, that all living things need air for respiration. But seeds don't need light, do they, for you have seen that they often start to grow right under the ground However, they will grow in the light and, since we want to watch them, we can plant them against a sheet of blotting paper in a glass jar filled with moist sand. Although they need moisture we could not plant them in water because they would not get sufficient air, but the moist sand will supply them with all the moisture they want and will hold them in position.

After a few days (the length of time will depend on the time of the year and the sort of seeds you have) you will notice that the seed swells very much, the skin commences to crack and the little white shoot that was tucked into the pocket just inside the wee hole in the skin pushes its way out through the hole and commences to get longer and longer You will notice that no matter which way you planted the seed the little first shoot will always grow downwards. So you will guess that it is the **first root** of the plant. After a little while, as the root is getting longer and longer, you will notice another thing happening. Another little shoot commences to come out It starts to turn a yellowish colour and soon it becomes green. No matter which way you had your bean planted this second shoot will grow upwards, so you can guess it will be the **leafy shoot** or stem. You will remember that you had already seen that it had leaves on it Now what about those fat green leaves? If it was a broad bean or a pea that you planted you will not notice anything happening to them for a while, but if it was a French bean you will see that the seed leaves are pulled out of the skin and come up above Here they open out and become quite green After a time you will see that the seed leaves, whether they grow up like those of the French bean, or stay underneath like those of the broad bean, begin to wither You can probably tell me why

Now while the shoot has been growing up and up and becoming green, the root has been getting longer.


I { Dry seed
II { Seed swollen
III { Seed coat cracked— young root coming out
II { Branch roots Root hairs
I { Cotyledons coming out First stem
II { Empty seed coat First true leaves
III { Growing point Stem straight Extensive root system

Stages in the germination of the French Bean

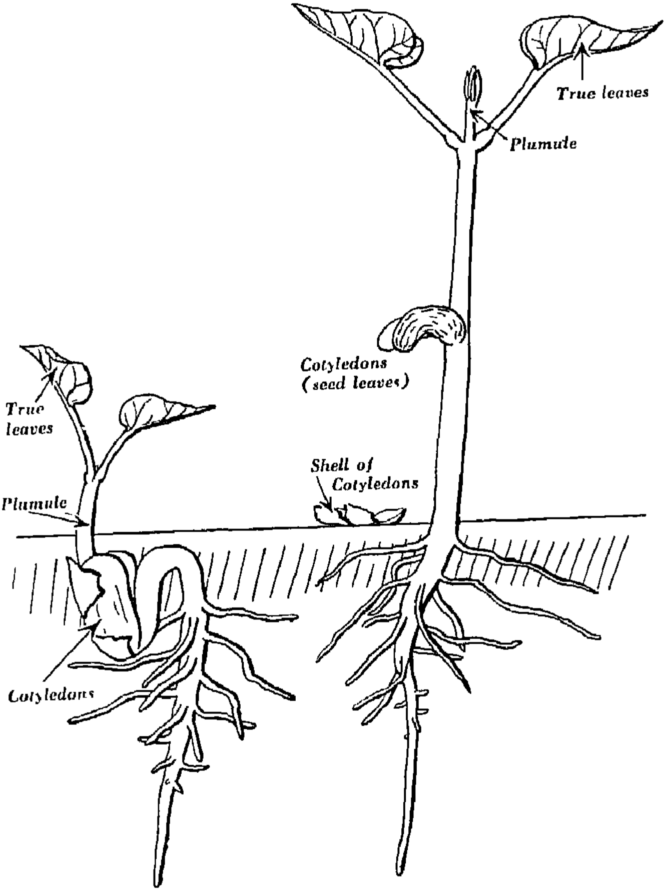
½ Nat size

In addition, small branches have been formed on the root and these smaller roots come off at angles to the larger root, so helping with anchorage Notice, too, a growth of fluffy, hairy structures on the root, from just above the tip to where the smaller roots begin to come off. These look like cotton wool Later you will find out something about their work

If you like you can grow some other types of seeds to see whether they all grow like the bean or peas Does the first root always come out before the shoot? Is the shoot always green? Does the shoot always have green leaves on it? Do the smaller roots always grow out from the first root? Some good seeds to grow and watch are pumpkin, maize, wheat. It is good fun to grow some of the seeds that you use commonly in the kitchen like soya beans, haricot beans, barley, and so on

How the New Plant was Made.

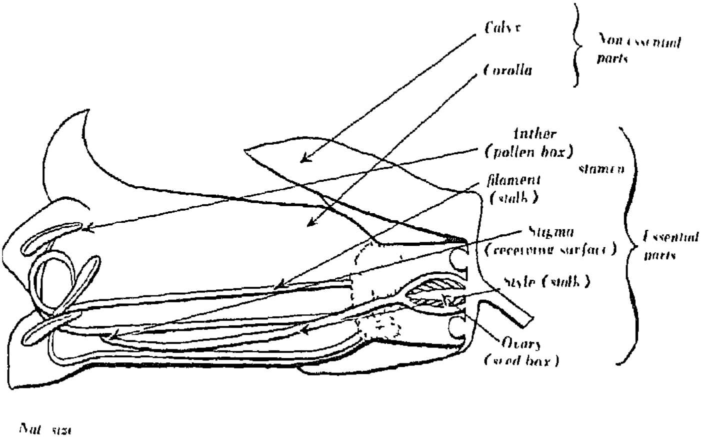
Now you have seen the young plant tucked away in the seed it would be interesting to find out where it came from and how it was made. The fruit or seed-pod of the plant comes after the flower, as you know, so it is certain that we should go to the flower to find out about this. The seed-pod, too, comes out of the centre of the flower, so it is here we should look for the beginning. Take a fairly large flower like a **Cobæa** or a **Poppy** or a **Snapdragon** or, better, a **November Lily** or a **Tiger Lily**. Right in the centre of the flower you will find a green, usually rounded structure, often with a long stalk coming from it and on top of the long stalk a flattened part In the poppy there is no long stalk. Open this rounded part and squeeze it gently Lots of tiny little round balls will come out These are the things that under some circumstances form the the seeds



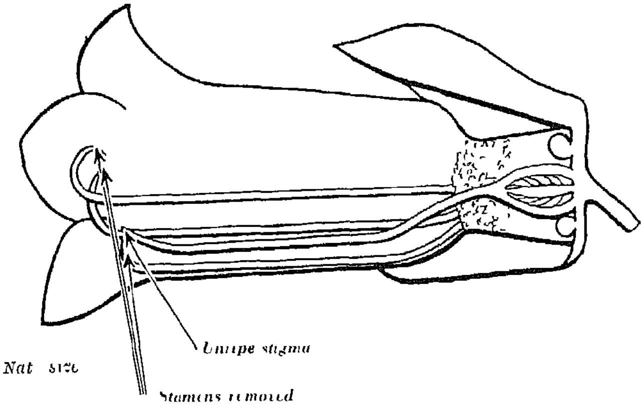
½ *Nat Size*

The **shoot** always grows up to the light and the **root** away from it In the first seedling shown here the seed was planted upside down but the root and shoot have turned round In the second seedling the seed was planted the right way up and so the shoot and the root have lost no time, being able to grow straight up and straight down, respectively

Look again at your flower. This time look just outside the seed-box part and you will see some little stalked structures which, if they are ripe, have yellow knobs on them. In the Cobæa there are five, in snapdragon there are four, and in poppy large numbers They are called **stamens** and the yellow material on the top is called **pollen.** This pollen is responsible for fertilising the little seed-like structures in the seed-box, that is, altering them so that they may grow into new plants Without the pollen they cannot grow into seeds. You can discover this for yourselves by a very simple experiment. You noticed the flat part on the end of the stalk of the seed-box or, in the case of the poppy, sitting right on top of the seed-box This is where the pollen drops. It is usually sticky or hairy when it is ripe. Now take a bud of some large, easily-handled flower before any of the pollen boxes have opened and before the seed-box in the centre is quite ready for pollen There will be no pollen on the pollen boxes and the flat part of the



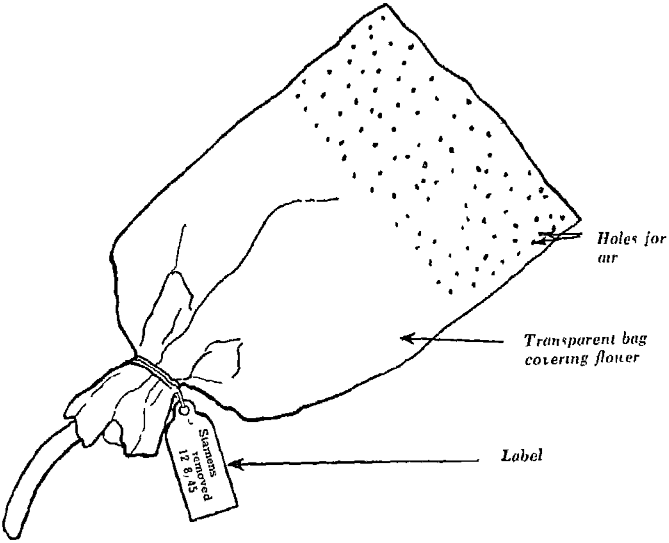
A Cobæa flower cut lengthwise to show its parts seed-box will not be sticky To make quite sure that you have the right kind of flower examine several of the same kind before you begin your experiment Be sure you have an unripe one in which no pollen has fallen on to the seed-box To make sure that none of its own pollen could get on when it ripens snip off the anthers (pollen boxes), and to make certain pollen from another flower is not blown by wind or carried by insects on to the flower cover it over with a transparent bag A transparent bag is the best kind, for you do not want to interfere with the flower any more than you can help and, as it usually gets light, you should let it get some in this way. You should put some holes in the bag, too, before you put it on, because the flower is used to getting air and needs it for respiration Tie the bag on firmly, but gently, so as to avoid damaging the stem Leave it for a few days Then examine the seed-box, break it open, and see whether the seeds have really been formed Are



Be sure to snip off the pollen boxes

they getting any bigger? Compare them with those from a bud.

Now to test whether you were right in your assumption, try putting some ripe pollen on to a ripe stigma and see whether this will cause a seed-pod to set fruit. Treat another flower just like you did the last one to



⅓ Nat size

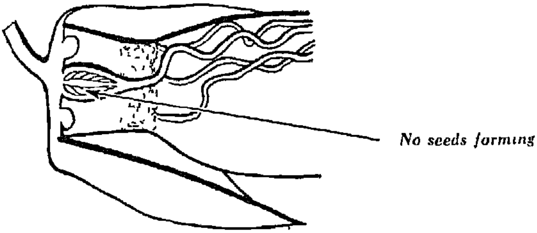
Cover your flower with a transparent bag

make sure that there is no pollen already on the top of the seed-box. Then, after a day or two, remove the paper bag and, if the stigma is ripe (you will have found out how to tell this by examining other flowers of the same kind previously) take some ripe pollen grains from another flower with a dry paintbrush and dust it on to the now ripe **stigma** (top of seed-box). Then cover the flower over with the transparent bag again and leave it In a few more days look at it again. Is the seed-box swelling?

From these two simple little experiments you will learn that there are two things necessary in order for seeds to be made—the little round balls in the seed-box and the pollen The pollen grows in little bags on the tops of fairly long stalks, as a rule, and it has to be carried in some way to the top of the seed-box.

Pollination.

For reasons which you will learn later most plants are constructed so that pollen is carried from the pollen bags of one flower to the top of the seed-box of another flower and not to its own seed-box

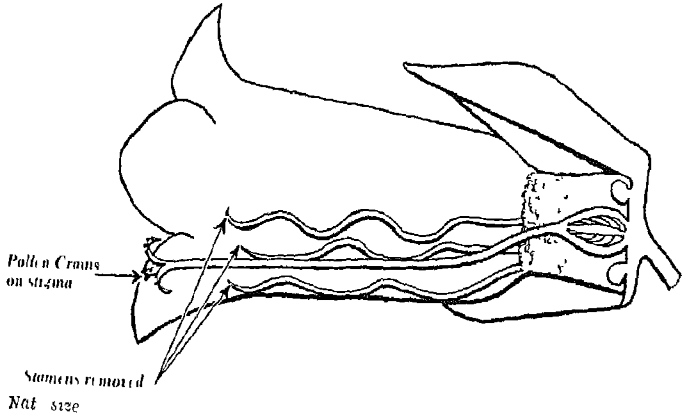


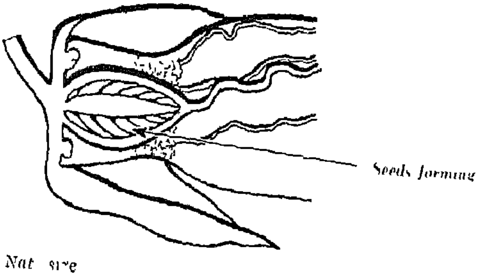
Nat Size

No pollen on the stigma and so no seeds

Sometimes it is carried by wind. Flowers which depend on **wind** to carry their pollen from one flower to another are usually very inconspicuous and have a great deal of very light pollen, for much of it is wasted.

Many flowers, however, depend on **insects** like **moths, butterflies** and **bees,** or on **birds** for carrying their pollen. These animals visit the flowers for honey (nectar) or for pollen for food Usually the animal which is attracted does not get sufficient from one





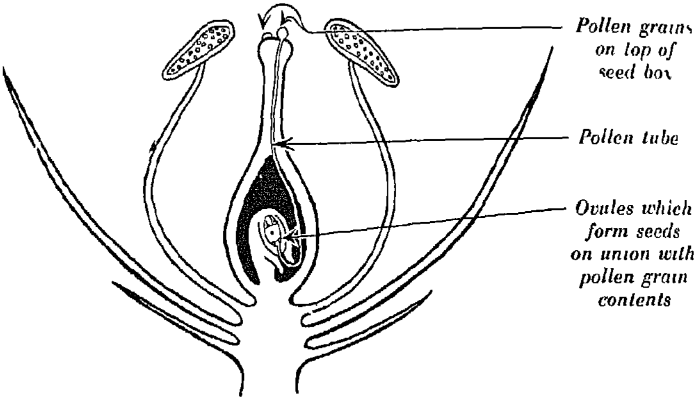
Hand Pollination
Pollen grains placed on the ripe stigma and so seeds are formed

flower and flies to another. In doing this it may accidentally knock some of the pollen from the first flower visited on to the top of the seed-box of the second flower Flowers are often constructed so that the top of the seed-box is in a good position for receiving pollen and the stamens are in a good position for brushing pollen off on to a visiting animal's body. Examine some flowers and see whether this seems to be so

Bird-visited flowers are usually large and often red, with plenty of Nectar (honey). Birds seem to be attracted to red coloured objects The nectar is mostly not very sweet-scented and the flower depends on the colour, rather than the perfume, to attract its visitors Think of the way some of these bird-pollinated flowers grow —**Hibiscus, Bottlebrush, Honeyflower, Banksia.**

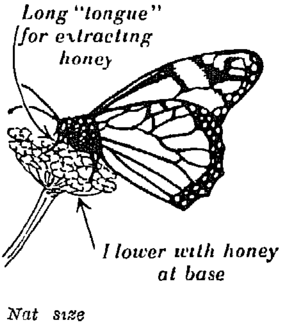
Hibiscus flowers are large and the nectar easily obtained Look closely into a flower. Notice the honey at the base Now notice the position of the stamens and you will see that the bird could hardly prevent some of the pollen being brushed off on to his bill or the back of his head Notice, looking at the bush, that there are usually a number of flowers open at the one time so, if a bird enjoys his feed of nectar and would like more, he has to hop only a short distance to reach another flower If the second flower is ready for pollen you can see by looking at it that the bird will almost certainly knock some off his head or bill on to the top of the seed-box So it goes on. Sometimes the bird flies to several flowers without coming to one which is quite ripe. In such a case he does not pollinate, but if there is an abundance of flowers and a good supply of pollinating agents some flowers are sure to be pollinated

Other flowers keep their pollen tucked well down at the base of the flower, often in a long tube, so that it is very difficult for anything except very tiny insects or insects with long tongues to reach them Now tiny insects like ants are not much use as pollinating agents for any except tiny flowers, for they can get quite sufficient for their needs from a single flower and so will not carry pollen from one to another. Many flowers have devices for keeping away ants who love flower nectar. But moths and butterflies have long, coiled tongues which they can use for pushing down into flowers and collecting nectar from the base of very narrow tubes. The tongue has a little brush at the end of it so that the insect can get a fair supply of nectar at one time Have a look at moths or butterflies feeding on some of these flowers.—**Lantana, Pittosporum, Larkspur, Delphinium, Nasturtium, Rondeletia, Bouvardia.**


Pollen grains on top of seed box
Pollen tube
Ovules which form seeds on union with pollen grain contents

A diagram to show how pollination allows seeds to be formed

When you are watching be careful to keep your shadow from falling over the feeding insects, for this disturbs them and they will probably fly away. Notice how the insect is usually provided by the plant with some kind of alighting platform, often the expanded petals, and notice how quickly he coils and uncoils his long tongue Notice, too, that one drink is not enough and, as a rule, he can usually find another flower of the same kind close by. In doing this the butterfly will often accidentally place the pollen from one flower on the top of the seed-box of another flower Most

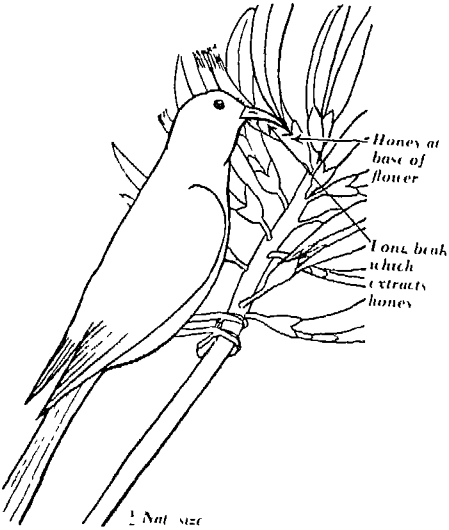

Long "tongue" for extracting honey
Flower with honey at base
½ Nat size

The **long tongue** of the **butterfly** can get honey from the base of tubular flower In this way moths and butterflies carry pollen brushed accidentally on their bodies

moths fly at night and heavily-scented white flowers are usually moth-pollinated You will notice several things about such flowers—the leaves are often dark, glossy green and the flowers waxy white The scent is usually much heavier at night time. You can tell why these things are so

Pittosporum, light-coloured **Oleanders, Jonquils** are usually pollinated by night-flying moths. You will be able to find many others

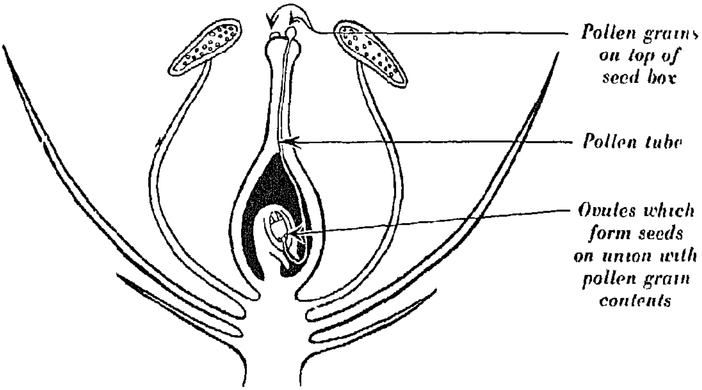
Bees visit flowers for nectar, too. This they use for food for themselves as well as for the young bees at home. Bees, as you know, are social animals, and the workers take a great deal of food home to the hive Nectar is one of these Bees do not have such long tongues as butterflies and moths and can only get nectar from fairly open flowers or flowers with a fairly wide tube Some flowers which provide bees with nectar as food are **Salvia, Snapdragon, Calendulas.** You will be able to find many others


Honey at base of flower
Long beak which extracts honey
½ Nat size

Many **birds** act as pollinating agents

But bees also collect pollen from flowers and take this home to the hive There it is pounded into a substance called bee bread. Some open flowers which are visited by bees are visited for pollen and have little or no nectar. Such flowers have to provide a great deal of pollen for, in addition to what is used for making seed and wasted by being spilled or dropped on to a flower which is not ripe for it, or already has some, sufficient has to be provided for the bee to collect some So flowers which are visited by bees for pollen have a great supply of it Some flowers of this kind are:—**Poppy, Teatree, Camellia.**

Watch bees at work on a bed of poppies See how they deliberately collect pollen and busily stuff it into bags on their legs. Notice that some of it spills over and lodges on those same hairy legs, only to be knocked off, perhaps on the top of a seed-box when the bees fly off to another flower Notice how many flowers one bee visits before he flies off with his treasure.


Pollen grains on top of seed box
Pollen tube
Ovules which form seeds on union with pollen grain contents

Look at this diagram again and see how the seeds are made

So you see there are many ways in which the pollen can reach the top of the seed-box. I have only told you a few Your garden and the bush will tell you much more It is well worth patient watching to see the process going on

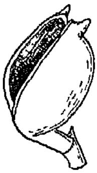
Of course you are anxious to know what happens to the pollen after it falls on to the top of the stigma. This is something which you cannot easily see for yourself unless you have a microscope, so I shall tell you. The tiny pollen grain grows. It puts out a long tube which grows right down until it reaches the tiny little round structures in the seed-box The contents of the pollen grain are then emptied into this round structure through the tube This causes a seed to be formed. So you see it takes one pollen grain for every seed that is formed. What do you think happens to any pollen grains which are left over?

Fruits.

When the seed is formed it starts to grow But that is not all. The whole seed-box commences to grow. This seed-box with seeds that have been made fertile by pollen is called a **fruit.** It doesn't matter whether the fruit is an edible one like a pear or a peach or a cherry or one which you call a vegetable like a broad pea or a pumpkin or a dry one like the pod of a wattle or the capsule of a poppy—if it has seeds in it it is called a fruit.

Now that the fruit has been formed the seeds have to be deposited in some way or another on the ground where they will grow Of course, there are always many more seeds produced than can possibly develop unless the earth is going to be covered with only one kind of plant Since we know that this is not so we know, too, that a great many seeds must be wasted But some do reach a good growing place and some of these grow

Let us find out the way in which some of them reach—or sometimes reach—a good growing place Some fruits are good to eat. Lots of animals like to eat juicy fruits Now when they do they often discard the seeds (throw them out on to the ground) and there they may grow The animal, even the human animal, hardly ever worries about whether he throws them on a good place for growing or not But sometimes he does—just by accident Cockies peck at the centre of a **Sunflower** with its ripe fruits and some of the grains fall on to the ground. Birds eat the sticky berries of the **Mistletoe** and the seeds stick to their beaks This worries the birds very often and they rub their beaks on a rough surface to get rid of the sticky nuisance—this rough surface is often the bark of a tree. There the seed may remain sticking until

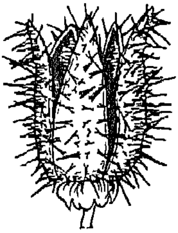


When the seeds have been formed the whole seed box grows and forms a fruit

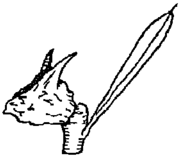
½ *Nat size*

some rain comes along and lodges in the roughness made by the bird's beak This may cause the seed to grow and another **Mistletoe** plant starts to develop at the expense of the tree

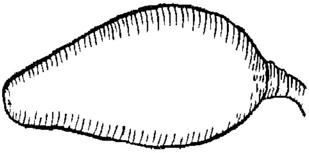
That's one way in which seeds reach good places for growing. Suppose we take an excursion to see what we can find out about how seeds and fruits are scattered. This is what I found when I took just such an excursion On the way down to the bush I noticed some fluffy things flying about I caught one and found that it was a little fruit of **Thistle** with a delicate little parachute of white. This kept it in the air for a long time so that, with a good breeze, I guess it could have gone a considerable distance. Close by I heard a series of short, sharp explosions It was a very hot day. I looked round to see what could be the cause of it. On a fence nearby a **Dolichos** creeper was in full fruit As the pods burst open they gave a little pop



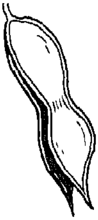
Fruit of THORNAPPLE (Datura) has many dry seeds



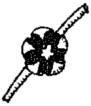
MOUNTAIN DEVIL (Lambertia) has two winged seeds



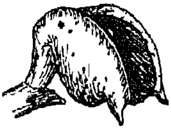
WOODY PEAR (Xylomelum) has two large, winged seeds



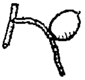
Pod of WATTLE (Acacia) has several dry seeds



TEATREE (Leptospermum) capsule produces numerous very fine seeds



HAKEA has two winged seeds



NATIVE CURRANT (Leptomeria) berry has one seed

½ Nat Size

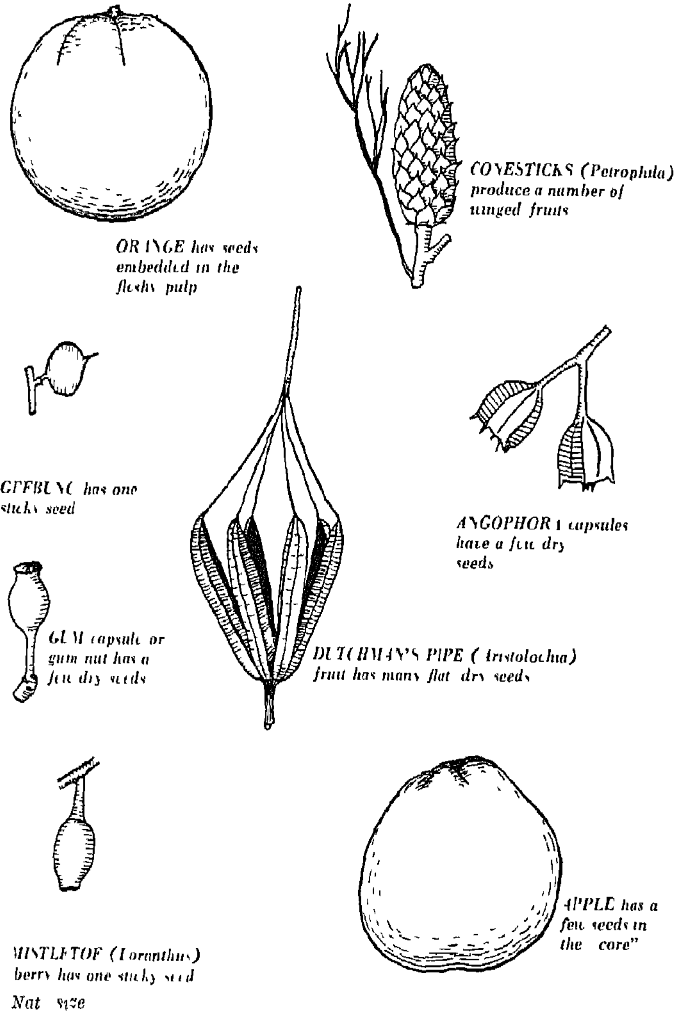
Have a look at these fruits and find out how they scatter their seeds.

and the seeds were flung quite a long distance away. While I was examining these I chanced to bend down to discover a great host of little brown fruits clinging to my stockings I pulled one off. It was the fruit of **Cobblers' Pegs,** which has two strong claws which it uses for clinging Many seeds and fruits use this way of travelling. Down in the bush I found some ripe, succulent **Geebungs** — juicy and sticky, and I guess the birds which take them for food would get rid of the hard stone in the centre as soon as they could I found some hard fruits of the **Hakeas,** too Searching carefully I found one which had just split open I saw two winged seeds inside. Taking them out I noticed how neatly the seed fitted into the depression in the woody case of the fruit covering I tossed one into the air Instead of falling straight down the wing caused it to twirl. This, I thought, will surely help it to be carried some distance *Why do you think this is so?*

I found lots of **Wattle Pods** open so I guessed that they must have got rid of their seeds by bursting the pod Some showed the seed-pod very twisted after it was empty, indicating a quick movement which would push the seeds out The **Woody Pear** has two very beautiful winged seeds like **Hakea.**

Groundberries and **Fivecorners** are good to eat I found them by searching in the low bushes. Many birds must find them good. I examined the hard stone in the centre. Birds would probably swallow that stone quite frequently It would then pass out with the excreta, not only unharmed but with the hard coat softened and partly decayed, so that the seed could get out more easily.

Then, at home in the garden, I found a ripe **Poppy Capsule.** It was standing erect and was dry and brown. I looked at it and found a series of tiny holes



ORANGE has seeds embedded in the fleshy pulp

CONESTICKS (Petrophila) produce a number of winged fruits

GEEBUNG has one sticky seed

ANGOPHORA capsules have a few dry seeds

GUM capsule or gum nut has a few dry seeds

DUTCHMAN'S PIPE (Aristolochia) fruit has many flat dry seeds

MISTLETOE (Loranthus) berry has one sticky seed

APPLE has a few seeds in the "core"

½ Nat size

Have a look at these fruits and find out how they scatter their seeds.

just below the flat cap I shook it as though I was the wind and out came a stream of tiny seeds.

What a lot of different ways seeds have of getting to places where they can grow!

I arranged all my seeds and fruits in groups according to the agent which helped disperse them This is what I got.

How Seeds and Fruits are Scattered

1 By wind—
    Seeds are very light—**Poppy.**
    Seeds have a wing—**Hakea.**
    Fruits have a parachute—**Thistle.**

2 By sticking to animals—
    By hooks—**Cobblers' Pegs.**
    By being sticky—**Paspalum.**

3 By exploding—
    Dolichos.

4 By being eaten by animals—
    Eating the fruit and leaving the seeds—**Orange.**
    Swallowing the seeds and passing them out—**Fivecorners.**
    Eating the fruit and planting the seed—**Mistletoe.**

You should be able to find lots more seeds and fruits and fit them into this plan You will probably also be able to add some more sections to it

It is evident that most plants which have been successful on the earth have found an effective way of spreading their seeds. Why do you think that it is essential to success that plants should have done this?

Photo H T Reeve

The Possums are marsupial mammals

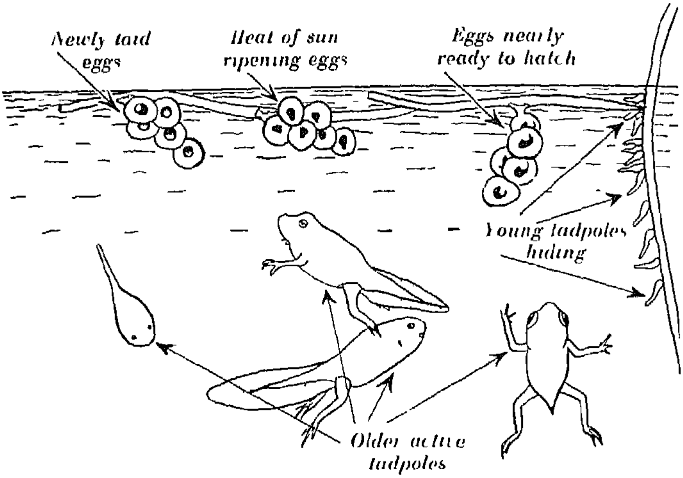
How Animals Produce other Animals like Themselves.

Animals, too, are able to produce new animals like themselves The baby animal is never exactly like the parent; sometimes it is so much like it that you can easily see the resemblance, like the **calf** or the **foal**; sometimes it is so different that you would not see any relationship by just looking at it, like the **caterpillar** of a moth or butterfly or the young of a frog (**tadpole**).

There are many different ways in which animals may produce young, but they may be grouped into two main divisions · (a) Animals which produce live young like **humans, cows, cats, rabbits,** some **fish,** some **snakes**; (b) animals which lay eggs which hatch out into young such as **birds, insects, frogs** and **toads,** some **lizards** and **snakes,** and so on

Animals which are cared for inside the mother's body until they are born are usually fairly well able to look after themselves soon after they leave the mother's body. Calves and foals can do this very quickly; kittens and puppies need great attention from their mothers for some time after birth, human babies are a long time becoming quite independent While some of the less highly-developed animals produce live young the most highly-developed of all, the **mammals,** almost always do so. A mammal is a furred animal which suckles its young Among the mammals there is a very interesting group called the **marsupials.** To this group belong the **Kangaroos** and **Wallabies,** the **Native Bear** or **Koala** (pronounce kŏ'la), the **Bandicoots,** the **Possum,** and all the animals which have a pouch or **marsupium.** Opening into the pouch are the mammary or milk glands. When the young of a native bear, for example, is born, it is very tiny and immature It is completely naked and blind and would fit on a sixpence As soon as it is born it hurries into the mother's pouch There it attaches itself very firmly and there it remains, without moving, for many months Meanwhile it is growing and developing, becoming covered with fur and gaining eyesight. After this it becomes independent. Some **marsupials,** as you know, allow the young to ride in the pouch long after they have need for this protection The **Kangaroo** is a good example You often find a fair-sized "joey" quite well able to hop and to take care of himself taking refuge in his mother's pouch

Let us now have a look at the way in which some of the egg-laying animals make new animals like themselves We might start by examining the life history of a **frog** or **toad.** These animals are amphibians, spending part of their life in water and part on land The early stages are spent in water, in stagnant or slowly-moving streams You will find plenty of eggs (spawn) in such pools The eggs or spawn are usually laid at night. The male frog holds the female by the back This contact causes her to deposit the eggs. At the same time the male passes out sperms (corresponding to the contents of the pollen box of a plant) which fertilise the egg A **fertile egg** is one which is able to develop The bubbly, colourless masses of unshelled eggs look like grains of tapioca floating about, never very far below the surface For, since they have nothing but the heat of the sun to hatch them, they cannot afford to be too far down Pick up a string of toad's eggs (this is how they are usually laid) or a mass of frog's eggs Notice how difficult it is to prevent the slimy mass slipping from your fingers. This protects it from being eaten by birds, who would also find it difficult



From egg to mature toad

to pick this slippery mass up in their beaks And, since they need to be near the top to get the warmth of the sun, they also need some protection from preying birds. Eggs are always good food because they are packed with nourishment for the young animal. If you examine the frog's eggs closely you will notice that inside the outer clear layer of jelly there is a dark spot This is the egg proper, corresponding to the yolk of the hen's egg, while the jelly on the outside corresponds to the white Toad's eggs are often laid in long strings or in separate bundles of three or four Frog's eggs are laid all together in a large mass and there are usually bubbles of gas among them to help to keep the mass afloat

You can watch the eggs hatch if you put them in a jar of water and keep it in the sun Every hour or so you will notice a difference The black spot is a spot no longer. It has become long and thin Soon you can make out the shape of the tadpole-that-is-to-be still inside the egg You will notice the long, flattened part which is the tail Then, the little black creature begins to wriggle violently and soon he has pushed his way out of the jelly If the weather is very warm all this may happen in a day If it is cold it may take several days or even weeks You see how dependent on warmth these creatures are It is just as well, for it would be no use their depending on their parents, who take no interest in them after the eggs have been deposited

One after one the little tadpoles will arrive until the egg mass is nothing more than a mass of jelly bags empty of their valuable cargo. At first each tiny creature has no eyes, mouth, arms or legs. It remains clinging to the green weed that almost invariably floats about in froggy pools. You should see that there is something like this in your jar or aquarium so that the wee tadpoles have a resting place after their struggle to get free from the egg

For a day or two it will remain like this and you will begin to think that tadpoles are not very interestings things after all But then they have been busy getting used to a new world and developing mouth and eyes They develop gills, so that they can use air dissolved in water for respiration, but these are almost entirely covered by a flap of tissue and very difficult to see

Soon they begin to swim about, eating small water plants or the bacteria which are responsible for causing the vegetable material in the water to rot. As the animals get bigger you will be able to see gill slits on the sides of the body, just below the head Under these are the gills Notice the water the tadpoles are constantly taking into their mouths. This passes over the gills which take out some of the oxygen for respiration

As the tadpoles grow a fold of skin appears over the upper part of the body It is joined on to the body all round except on the left side. Here an opening is left—you can see it quite clearly—to enable the water carrying the air for respiration to pass out over the gills. In a short time you will see two little buds appearing on either side of the tail It soon becomes clear that these little stumps are the beginning of the long hind legs of the frog. When these begin to form the tadpoles usually lose their appetites for a time, all their energy seemingly taken up on this. At the same time a great many other changes are taking place, some of them not so easy to see. The eyes are getting much bigger, the gills are getting ready to change into land-breathing lungs, and the mouth is changing from a sucking mouth to a mouth with a tongue used for catching small animals on the wing Soon a time comes when the mouth is no longer of any use for sucking and not as yet ready for catching animals on the wing For a time the tadpoles cannot feed at all At this stage they depend only on the food stored up in their tails which now begin to get a little smaller Soon the forelimbs appear One slips out from the hole on the left side that was left for the water passing over the gills to escape and is usually visible before the other one which has to tear the cover away before it is free.

Now the tadpole is nearly ready to leave the water as a fully-fledged frog or toad, but by no means its full size It still has its tail, which will serve as a supply of food, while the animal is getting used to its new land ways of living It can now only stay under water for a short time, for it has no means of using the air in water for breathing as it once could For quite a time the young frog does very little But once his tail food has been all used up he has to depend on his own agility in catching prey and he becomes very active indeed

When your tadpoles reach the frog stage you should liberate them near water, for you cannot easily keep them in an indoor aquarium Don't forget, either, that as soon as they commence to reach maturity you need to provide them with some means of crawling out of the water so that they can get air A stone protruding or a piece of cork floating will do

You are sure to want to know how long this story takes. There is no answer If the weather is warm and there is plenty of food for the animals, probably six to eight weeks, but maturity may be delayed for a long time in cold weather or when the food supply is low

Moths and Butterflies.

Moths and butterflies lay eggs which grow into creatures very different from their parents, too Let us look for their eggs Since the mother takes no interest in the eggs after they have been laid it is important that she should lay them on a plant which will serve for food She will do this if she possibly can Of course, if you keep your insects in a box so that they cannot get out they will eventually lay the eggs there, but if they are at liberty they will often fly long distances to get the right sort of plant Some insect young (**caterpillars** or **larvae**) will eat a great variety of plants, others will only eat one particular kind The mother usually deposits the eggs on the under-surface of the leaf where they will not be so easily found by birds, for these, like all eggs, are packed with food.

Let us hunt for some **insect eggs.** We will search under the leaves of many plants Sometimes we find eggs laid singly like those of the **Wanderer** or the **Cabbage White Butterfly;** sometimes we find them in clusters like those of the **Emperor Gum Moth.** The warmth of the sun hatches them, sometimes a few days after they are laid, sometimes many weeks or months

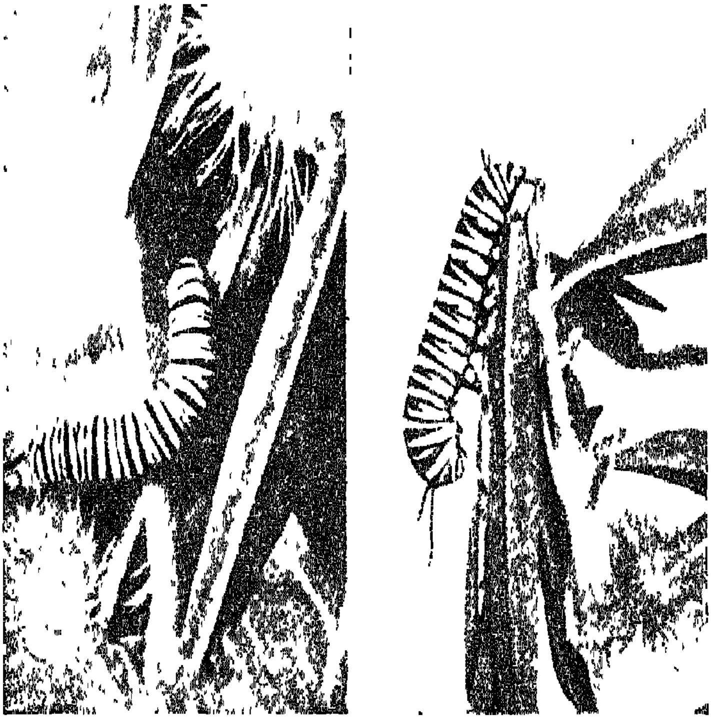
Let us follow the life history of one of the commonest, but most beautiful, of the butterflies, the **Wanderer or Monarch.** If you have Native Cotton growing in your school or home garden you can leave the eggs on the plant to hatch If you have not you should make sure that you will be able to get some to feed the **caterpillars** when they hatch, for they are very particular about their food. It has been reported that they will eat rose leaves, violet leaves and other soft types, but I have not been successful in persuading them to do so. As soon as they hatch—tiny, naked **caterpillars**—they commence to feed, starting on the soft edge of the leaf and nibbling rapidly. As they eat rapidly they grow rapidly, casting off one skin after another. As they get bigger you can make out their marking better They are quite conspicuous with their cross markings of yellow and black, yet birds rarely touch them It has been suggested that they resemble another species of caterpillar which is poisonous and the birds are deceived Certainly they are left untouched. Notice the feelers on the front which are constantly moving when the animal is active and the horn-like structures at the rear You can see the breathing holes on this **caterpillar** well, too

After a few weeks of vigorous life the **caterpillar,** which by this time is 2-2½ inches long, becomes very sluggish This is the time to watch carefully, for the **caterpillars** are about to make their **pupas.** They usually choose a place which is in concealment, often in the grass about where they are living or in a dark corner of a box if they are confined Often they begin at night This is probably for protection because the creature is quite helpless during this stage. At first it attaches itself firmly by the tail-end and glues itself on Then, curling the head up towards the tail it splits its last caterpillar skin This is shed and now it is not able to move for it has its body enclosed in a remarkably small and an amazingly beautiful pupal case of an iridescent blue with gold markings. There it remains for some time, perhaps through the winter or only for a couple of weeks of midsummer. The **pupa** becomes much darker during this time and the wing markings can be seen, but otherwise it looks very much the same in structure. Inside, however, great changes have been going on. Then one day a slit occurs down the back of the **pupa**—again on a hot day, for this, too, depends on the heat of the sun—and a brownish **butterfly** begins to emerge At first it is crumpled and squashed up, but as it moves out of the pupal shell the body begins to elongate, moving backwards and forwards with a writhing motion The wings fall out like crumpled pieces of silk, but they, too, are moved constantly Gradually they unfold and straighten When they first come out they are quite moist, but they dry rapidly. The coiled tongue of the insect is moved backwards and forwards to get ready for use, too. The two pairs of legs (the third pair does not develop in this butterfly) are also continually moved. Soon the wings are quite dry and expanded The insect moves them out and in a few times. Then, all its body parts tested, it moves off on its first flight This first flight is usually a short one But, by this time, it is quite able to fly a long distance and, once it rises a second time, you are not likely to see it again

A butterfly does not live very long as a rule It sips a little nectar from tubes of long-tubed flowers, finds another butterfly of the same kind, but different sex (the sex organs develop only in the butterfly The caterpillar is sexless) and mates with it The female then deposits the eggs in a suitable place and often dies soon after

All moths and butterflies follow the same pattern in the life history, but they all differ slightly, of course. The **Silkworm** is an interesting and easy one to watch, and it is very easy to watch the **cocoon** being spun. **The Emperor Gum Moth** spins a fibrous cocoon from which the beautiful moth has to claw or file its way There are so many of them which you can study that it is difficult to suggest which might be best, but beginning on page 150 is a list of some of them, with their food plant (so that you will know where to look for the eggs), the colour of the larva, the length of time it takes to pupate (this is for warm weather), and what the imago or perfect insect looks like.

If you have **cocoons** indoors you can often watch the whole process of emergence in great detail, for the **butterfly or moth** usually takes much longer to come out if it is kept away from the heat of the sun.



[Photos R D Lee Blocks by courtesy "Wild Life", United Press, Melbourne]

The caterpillar of the Wanderer Butterfly feeds on the leaves of the Wild Cotton Plant Fully grown, it seeks a suitable resting place Fixing itself with a silk thread at the hind end it hangs head downwards The body is banded with alternating lines of black, white and yellow.

The Eggs of Animals.

Many different kinds of animals lay eggs On the coloured picture opposite a few of these are shown

Row A.

1 Eggs of the pond Snail Each mass is covered with a protective kidney-shaped shield of jelly. Nat size.

2 Eggs of cricket deposited in a cavity in a small block of wood They are well concealed ½ Nat. size

3 Eggs of a Robin, well protected in the nest ¼ Nat size.

Row B.

1. Eggs of a small Butterfly deposited on a leaf which will provide food for the caterpillars when they hatch. Nat size

2 Frog's eggs in their protective gelatinous sheath. Nat. size

3 The eggs of the Lacewing suspended on fine threads Nat size

4. The egg case of a Mantis from which a great many tiny young will emerge ½ Nat size.

5 Eggs of a plant bug deposited with remarkable regularity round the stem of a plant Nat size

Row C.

1 Egg case of the Common Port Jackson shark. ½ Nat size.

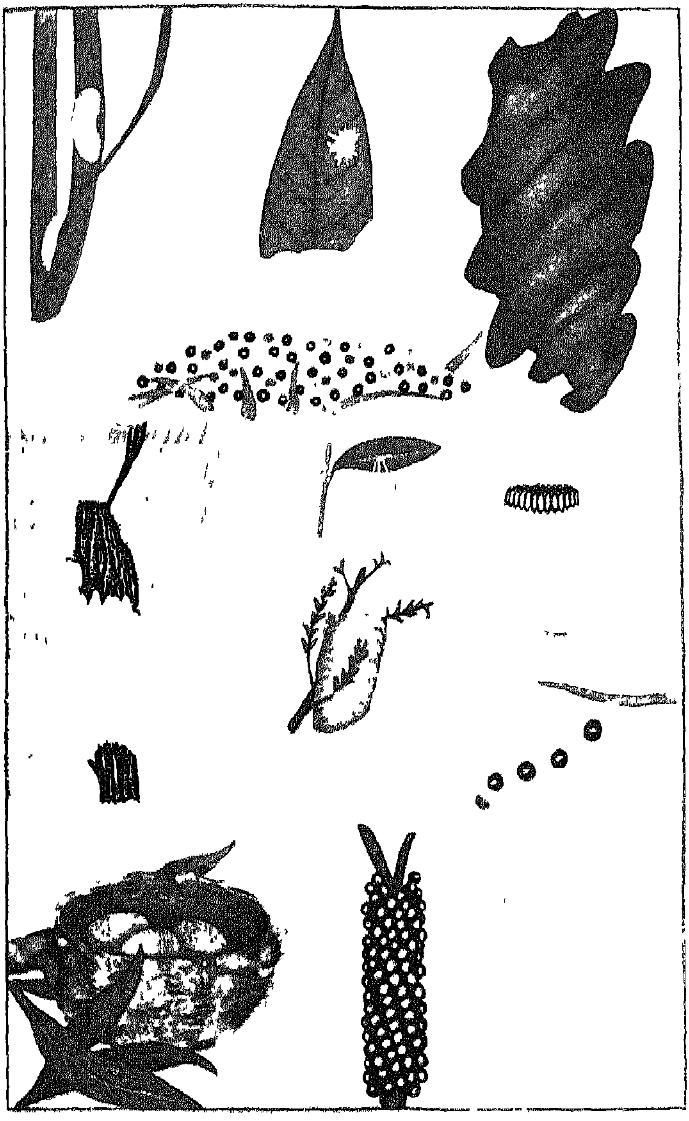
2. Egg raft of the Mosquito Nat size

3. Eggs of a small ground Lizard. Nat size.

4 Eggs of a Toad. Nat size

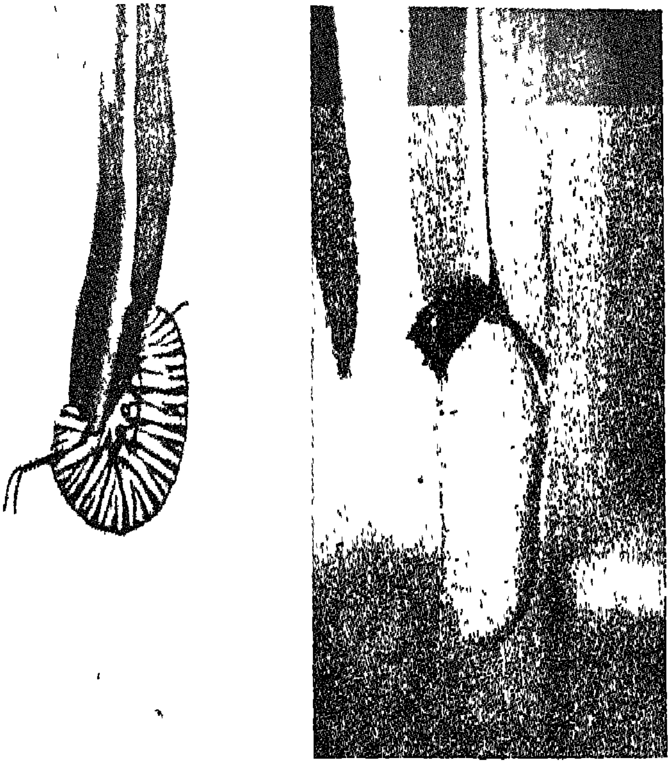
5 Eggs of the garden Snail ½ Nat size

6. Spider's egg case containing a number of eggs The tough fibres of the case are protective Nat size



Many different kinds of animals lay eggs

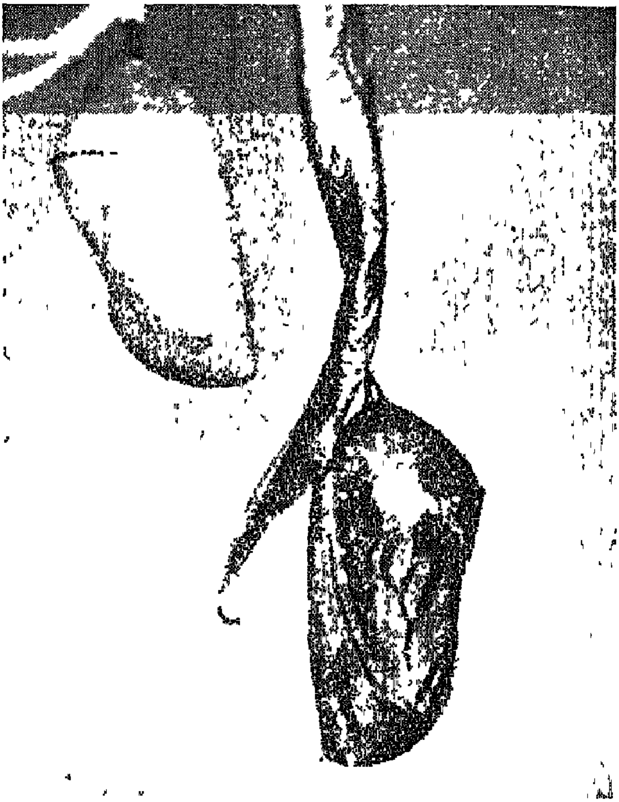
In the letterpress opposite, the numbering commences in the top left-hand and runs down, giving three irregular rows



[Photos R D Lee

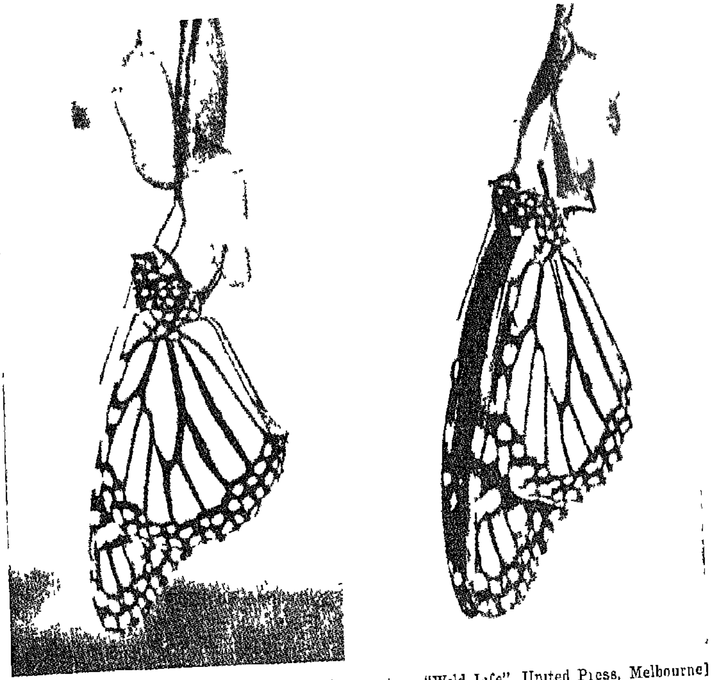
Blocks by courtesy "Wild Life"]

The caterpillar is now mature and ready to begin the pupal, or resting stage The pupa, a lovely jade green with gold spots, remains unchanged for some time



[Photo R D Lee
Block by courtesy "Wild Life",
United Press, Melbourne]

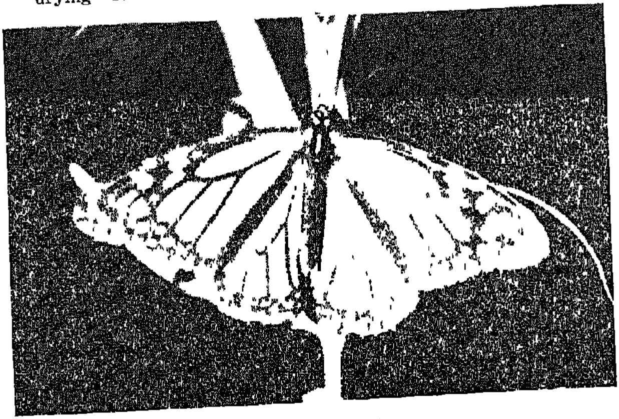
The pupa changes to a dark purple colour, revealing the wings beneath



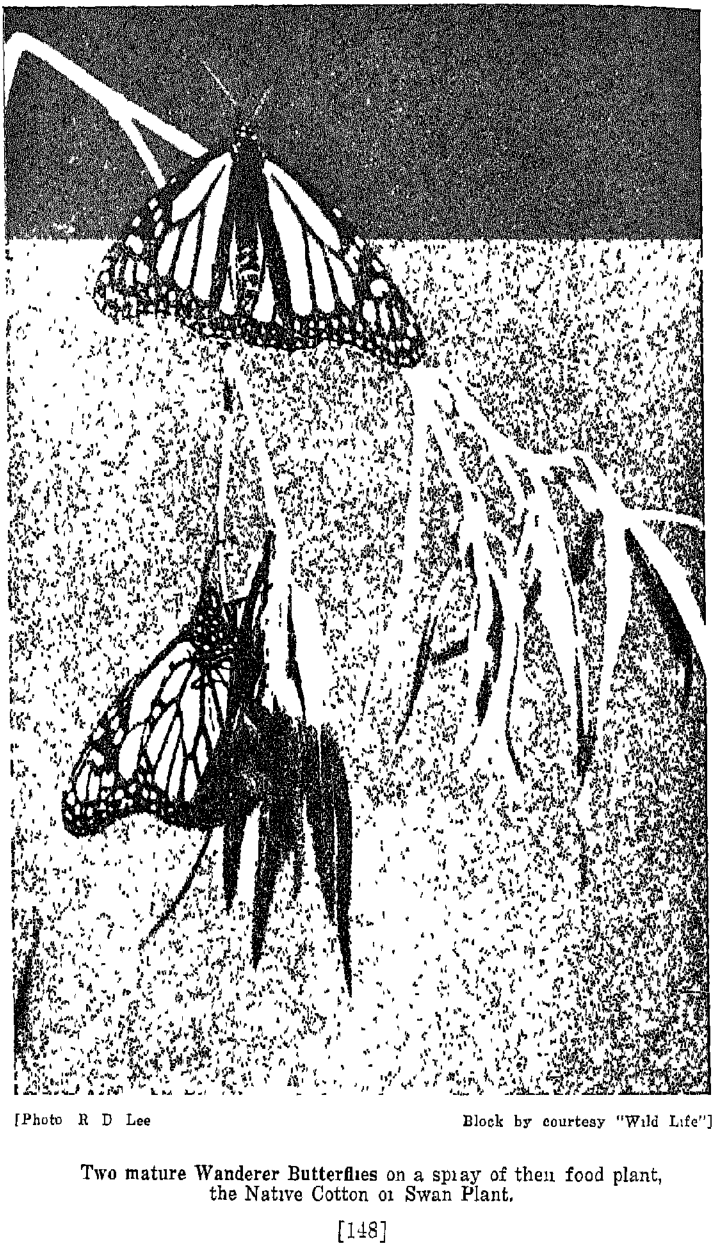
[Photos R D Lee

Blocks by courtesy "Wild Life", United Press, Melbourne]

The **butterfly** emerging from the pupa case, stretching its wings and drying Note the full **pupa** also in the left-hand picture

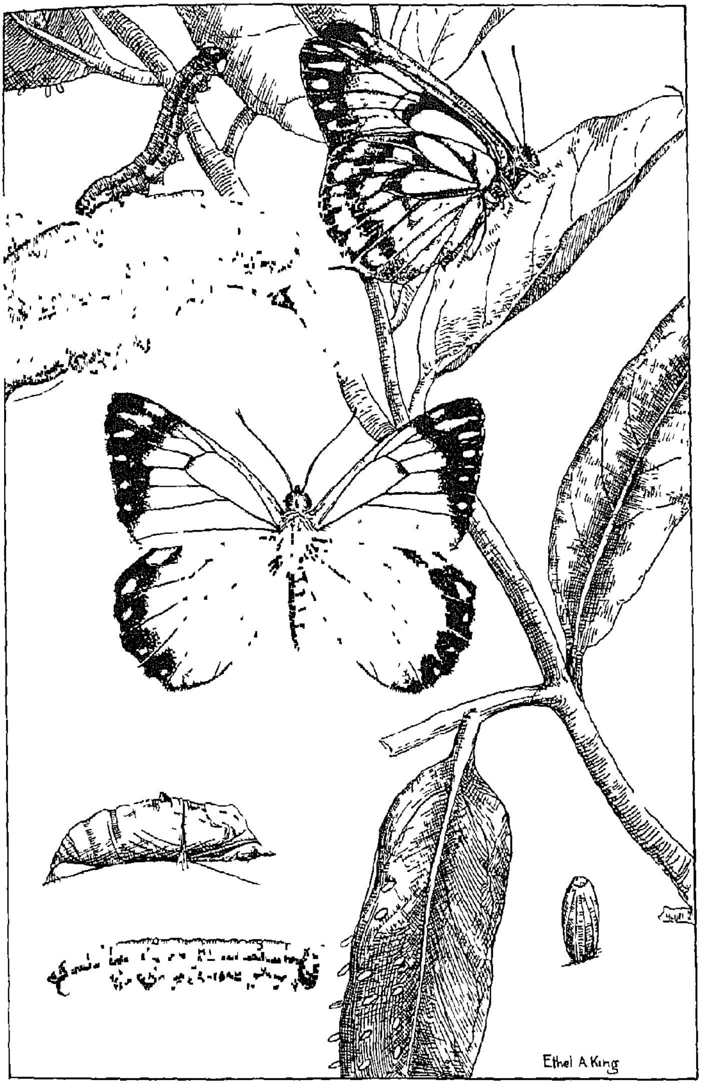


Ready for Flight.



[Photo R D Lee Block by courtesy "Wild Life"]

Two mature Wanderer Butterflies on a spray of their food plant, the Native Cotton or Swan Plant.



[By courtesy Royal Zoological Society]

The life history of the **Caper White Butterfly**, whose caterpillars feed on the wild Caper (Capparis) of the western country The butterflies are dainty, slow-flying, often travelling for long distances and frequently seen in coastal districts

HOW TO RECOGNISE THE STAGES OF SOME COMMON MOTHS AND BUTTERFLIES

TYPE	LARVA	PUPA	IMAGO	FOOD PLANT
Gum Pinara Moth	Velvety blue, fawn or grey Fringed on side with velvet blue fold about middle of back Eats only very young leaves (Autumn, Spring)	Oval Pink, White or Green	Sandy coloured	Eucalypts or gums of many kinds
Pinara Moth of Apple	Bluish grey Roll and strip leaves	Chestnut brown	Fawn and pink	Apple
Cup Moth, Painted and Mottled	Flat, covered with spines stinging (Spring-Summer)	Hard and cup shaped	Brown and white Rounded body	Eucalypts or gums, tea-trees, and many other types
Saunders Case Moth	In case Throughout year Eggs hatch Jan April	Brown, long case	Brown, thin winged Female wingless	Eucalypts or gums, rose, etc Almost any plant
Leaf Case Moth	In case Throughout year Hatch Jan April	Case, covered with leaves	Brown	Eucalypts or gums, grass, etc Almost any leafy plant
Lictor or Faggot Case Moth	In case Throughout year Hatch Jan -April	Brown, covered with sticks	Brown	Almost any plant

HOW TO RECOGNISE THE STAGES OF SOME COMMON MOTHS AND BUTTERFLIES

TYPE	LARVA	PUPA	IMAGO	FOOD PLANT
Ribbed Case Moth	In case Throughout year Hatch Jan April	No sticks Case distinctly ribbed	Brown	Eucalypts or gums, and other related plants
Processionary Moths	Spiny, stinging, gregarious (Autumn Winter)	Silken bag, many together	Fawn Stout Very furry	Wattles, gums
Banksia Moth	Brown (Autumn)	Chestnut brown Pupates in ground	Forewings grey Hind wings brown	Banksia (Native Honey suckle)
Orange Moth	Black covered with fine hairs (Autumn)	Light brown in a silken web	Small, brown with black markings	Orange and other citrus plants
Vine Moth	Dark greenish black with yellow and red marks (Autumn Spring)	Brown Oval Pupates in ground	Black with yellow markings on forewings	Vine, and possibly other small plants
Silver Striped Vine Moth	Large, smooth greenish or brown (Autumn)	Light brown On twigs or underground	Brown with pink on hind wings A hawk moth	Vine (grape)
Dried Fruit Moth	Small, white 1 2 weeks	Cream coloured, surrounded by silken threads 1 2 weeks	Small Brown	Dried fruit

HOW TO RECOGNISE THE STAGES OF SOME COMMON BUTTERFLIES AND MOTHS

TYPE	LARVA	PUPA	IMAGO	FOOD PLANT
Darala Moth	Dark brown Hairy Very numerous 2 weeks (Autumn and Spring)	Brown 2 3 weeks	Brown with lighter brown shading with 2 black spots centre fore wing	Soft plants
Tomato Moth	Greyish white or green smooth 1 2 weeks (Autumn Spring)	Rich brown In ground	Small Fawn and yellow	Soft plants
Bluegum Moth	Pinkish fawn Smooth (Autumn and Spring)	Small brown	Small 2 shades brown	Many gums
Wattle Goat Moth	Pinkish yellow in wattle stem	Brown Cylindrical in stem 2-3 years	Large Brown and fawn	Wattles, particularly Black Wattle (Acacia decurrens)
Emperor Gum Moth	Large, green with red spines (Feb Mar Apl Oct Nov)	Brown Oval	Brown Eye spot	Eucalypts or gums, pepper
Cabbage Moth	Green, smooth ½-inch 2 3 weeks	Dirty white Woolly	Small Fawn	Cabbage, cauliflower
Wanderer Butterfly	Black and yellow striped	Blue with gold dots	Brown with black markings	Cotton bush (Asclepias)

HOW TO RECOGNISE THE STAGES OF SOME COMMON BUTTERFLIES AND MOTHS

TYPE	LARVA	PUPA	IMAGO	FOOD PLANT
Orange Butterfly	Smooth Blackish brown with yellow dots and 2 rows spines 1½ inches About 1 month (Summer)	Dirty white with greenish blotches About 10 days	Wings about 1 inch across, black and white Hind wings marked red and blue	Citrus plants
Bean Butterfly	Green Flat Milked by ants	Small Greenish brown	Small Purplish blue and brown	Leguminous and other soft plants
Cabbage White Butterfly	Green (Spring Summer)	Pale green	White with small black wing markings	*Cabbages, cauliflowers,* etc
Caper Butterfly	Brown Smooth (Spring Summer)	Greyish white, speckled black and yellow	White above with black on edge of wings Under marked black and yellow Migratory	Wild orange, Warrior bush, etc
Imperial White	Hairy, dark	Jet black, in a communal web	Greenish white, fringed with black	Mistletoe
Blue Fanny	Bright green, spotted with yellow Tail forked	Pale green, girdled, triangular	Black with central portion bluish-green or turquoise	Camphor Laurel

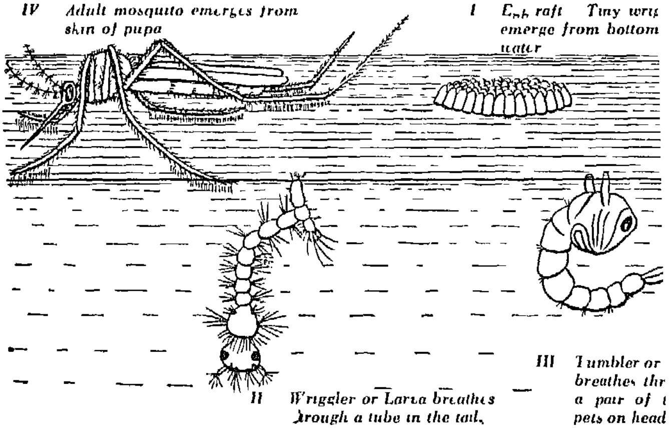
Some other Insect Life histories

The Life History of the Mosquito

As with other life histories the story of the mosquito can be read a little at a time as the animal passes from stage to stage.

The **eggs** of the mosquito are laid on the surface of stagnant water throughout the warm months In the common species here the **eggs** are glued together in groups, about 200 in each group, forming an elongated raft about 1/16 inch in length Within 24 hours, as a rule, these hatch, the small larvae or "**wrigglers**" being liberated through a door at the bottom of each elongated egg case The **wrigglers,** at first small, move actively about in the water feeding on vegetable matter and coming frequently to the surface where they lie suspended, head down, with a portion of the tail projecting. Through this protruding portion the animal gets its supply of air As the animal grows the skin moults After several moults and in about a week—the time varying with the weather—the wriggler is full grown, now measuring about ¼ inch in length and it passes into the **pupal** stage This is not a dormant period as it is in so many insects The **pupa** has a huge head and a breathing trumpet on the upper portion of the thorax so that, in order to breathe, it comes to the surface of the water and remains with the trumpet protruding The pupa, called a "**tumbler,**" lives an active life like the wriggler but it only remains in existence for about two days in hot weather During this period changes in the body are taking place and when the **imago** or **perfect insect** is about to emerge the pupa comes to the top

of the water. Here the pupal skin slits down the b
and the insect works its way slowly out of the dı
skin, rests for a brief period to dry its gauzy wiı
and flits away. This process is a very precarious
for the mosquito, for a slight movement of the wa
may cause it to slip off the very frail float formed
the pupal skin and so it drowns This happens qı


IV Adult mosquito emerges from skin of pupa
I Egg raft Tiny wrig emerge from bottom water
II Wriggler or Larva breathes through a tube in the tail.
III Tumbler or breathes thr a pair of t pets on head

Four times Nat size

frequently This explains, too, why mosquitoes a
unable to live in moving water for, while the wriggl
and tumblers would be safe, the emergence of t
perfect insect would be impossible. The matı
mosquito flies off, the male probably to get its fc
from sucking the juices of plants, the female to pieı
the skin of animals and to extract small portions
their blood for food. During this sucking process t
mosquito injects into the blood a fluid which m
contain in it germs of disease.

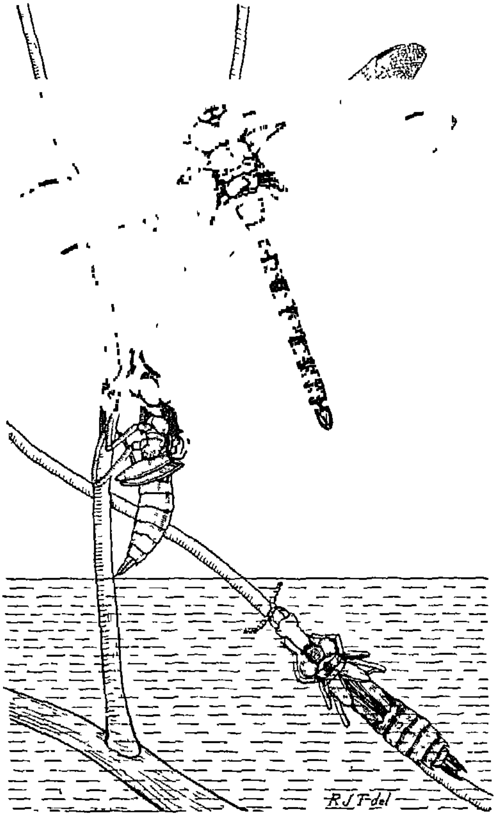
At least two serious diseases, malaria and yell
fever, are spread by mosquitoes in this way. All sta
nant water, the breeding places of mosquitoes, shoı

be destroyed wherever possible. If this cannot be done a film of oil (like kerosene) over the surface of the water will prevent the larvae and the pupae from breathing and so the life history will not be completed In some swampy, mosquito-infested areas the planting of swamp-loving trees has so drained the swamps that the mosquitoes cannot breed there

The Life History of the Dragon-Fly

These animals can well be studied at least from the nymph or larval stage in the classroom where they can be kept in muddy water. The life history can be followed out from week to week until the complete insect emerges.

The eggs are laid on the stems or under-surface of the leaves of water plants or, in some cases, floating on the surface of still or running water. When they hatch they produce the **nymph** or **larva**, a free-swimming creature with a stout body and three pairs of legs The lower lip can be thrust out for a considerable distance and grab passing food in the form of mosquito wrigglers, etc. The process of lying in wait and grabbing prey can be observed in an indoor aquarium The **nymphs** are most voracious creatures, consuming the **larvae** of dragon-flies smaller than themselves with great relish. As the **larva** grows it becomes too big for its skin and consequently moults. About 12 or 15 moults are necessary before the animal has finished growing. At this time it varies in length, according to the species, from ¾ to 1½ inches. Just before the final moult the animal becomes less active and disinclined to take food. It crawls out of the water, up the stem of a water plant or anything which is protruding. When keeping these animals in captivity it is essential to provide them with some means of emerging from the water at this stage The animal remains quiet for a short time. Then the skin bursts down the back and the insect pushes its head and front legs through the crack. Then, by attaching the legs to a support, the rest of the body is pulled from the old case. No longer is the insect an ugly nymph, but a **dragon-fly.** Gradually the little, tight-folded wings unfold In about an hour the beautiful gauzy-



Nat size

The nymph or larva of the Dragon-fly crawls out of the water and sheds its last skin to reveal the beautiful, gauzy-winged perfect insect winged **dragon-fly** soars away in search of food, consisting of insects, which it usually catches on the wing. The may-fly, a smaller, delicate creature, and the caddis-fly, whose larva clothes itself in a protective mud or stick case, form other interesting types to study They undergo similar life histories

All these creatures have two pairs of wings, beautifully veined. The may-fly has three long, fine threads protruding from the tail end and these probably help in balancing the insect There is no truth in the story that some of the dragon-flies are horse-stingers They live, as we can see by watching them, on small, flying insects.

Keeping Animals for Observation

Unless you have a very big garden with many different kinds of plants in it, it is difficult to study even butterfly or moth life histories satisfactorily If you are going to keep animals and observe them for any length of time it is necessary to have them housed properly and in such a manner that they do not require too much attention. Of course, it is quite useless to think about keeping even the smallest animals unless you are prepared to attend to them regularly

The first thing to remember about animals is that they will require both air and food, and some of them will require light, and others moisture Your house, too, should be of such a nature that you can observe the inmates without taking them out or without having to open a door or take off a lid.

For insects, the best and easiest sort of cage is one made of strong, light wood for easy carrying, with one side or the top made of glass so that you can see in, and two opposite sides of netting or wire mesh to allow a current of air to pass through continually In such a house you can keep insects and watch them without disturbing them at all If one side opens right out as a door it will be a very simple matter to clean the case out daily If you like you can have a shelf in your case with holes in it This is a safe way of keeping plenty of fresh food without having your caterpillars falling into water and drowning themselves For you can place the jar of water on the lower floor and allow the leaves to pass from the upper floor into the water through the holes. The caterpillars will be placed on the upper floor A layer of sand on the floor will sometimes save their lives if they fall, and make it easier for cleaning. You can just lift out the shelf each day and throw out the soiled sand

An easily-made temporary home can be constructed out of a strong boot-box, in the lid of which a large window is cut and pasted over with cellophane so that you can see in. Holes in the side of the box will supply air Unless you keep a cover of paper or card over the bottom it will soon become moist and break away. In addition, you cannot easily keep the food in water and so you will need to be constantly renewing it, but for docile caterpillars like silkworms, if you have a food source quite handy, this sort of housing will do

A similar wooden cage as that described for insects, with wire sides and a glass top, but larger and with a sliding tray in the bottom for easy cleaning, is suitable for small animals like small lizards. Sand in the bottom of the tray helps to keep it sweet and makes cleaning easy Some lizards are not easy to feed, others give no trouble Some will eat tiny fragments of meat, while many of them dote on earthworms, smooth caterpillars (some will even eat hairy ones), beetles and other small, living things Lizards are interesting creatures to watch. Some of them lay soft-shelled eggs and some produce their young alive You could house and watch **snails** breeding in a cage like this, or other kinds of small animals.

Larger animals like **Blue Tongue Lizards** and **Guinea Pigs,** which are great fun to keep, need bigger homes and are not easily kept at school unless some arrangement can be made for feeding them on the week-ends The best sort of cage or hutch is one with a wire-netting on part of the roof or one side and a removable bottom for cleaning. If you can keep them on the grass there is no need for a bottom at all, the difficulty of cleaning being thus removed

Guinea Pigs are especially interesting and easy to keep. They are very hardy, grass-eaters (and greatly enjoy many scraps from the kitchen, such as carrot peelings, pea pods and other delicacies), and show many interesting habits to the careful observer Being mammals, they are live-bearers and breed very rapidly The young are born remarkably advanced Although given milk by the mother, as all mammals are, they begin nibbling grass a very short time after birth, and are really independent of the mother in a few hours

Blue Tongue Lizards are also very interesting In a safe garden (where they cannot escape) they will live for a long time out of confinement and will keep down the snail pests, which they prize as dainty morsels, but they can be kept and observed in captivity. They should be given an opportunity to sun themselves daily and also some place in which to hide within their home

A great many interesting creatures can be kept in an indoor aquarium You have to be careful, however, how you mix your animals in an aquarium without knowing something of their habits, for many of them

[Photo H T Reeves]

A study of the Silver Wattle (Acacia dealbata) fringing a coastal creek The trees accompanying it are Eucalypts

[Photo K McKeown Block by courtesy Australian Museum]

Eggs of a long-horned tree grasshopper

eat one another If you have **Dragon-fly Larvae** or **Water Beetle Larvae** all the smaller animals will soon disappear, because these creatures are most voracious and eat a great deal of food consisting of their inmates You will lose your mosquito wrigglers and tumblers, your small tadpoles, and even the smaller dragon-fly larvae! If you want to study life histories of aquatic animals it is usually advisable to keep the animals of your choice in a jar or tank used specially for that purpose

If you want to keep any animals for observation you should set about it like this First, find out all you can about the way the creatures live in nature. Find out what they eat, where they live, whether they like light or dislike it or seem indifferent to it, and so on Then consider whether you could make conditions and provide food fairly similar to those to which the creature is accustomed. If you can you will probably have success with your experiment. If you cannot it is better to leave the animals where they are

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UNIT 7

What Sort of Plants Does Australia Produce?

Australia is a very beautiful and picturesque country, with some very lovely native vegetation Those of us who have lived here long enough love it, both for its beauty and its familiarity Those of us who are older know the joy of returning to beautiful places which remind us of earlier times And most of us enjoy the sensation of pleasure which beautiful scenery and lovely flowers give us. Of course, we do not all love the same kind of country Some of us love the rugged coast, others the rolling plains, some of us find it hard to make up our minds which appeals to us most There are some places, however, which appeal to a great many people Most people, too, love our wild flowers and our trees.

In Australia there are several different types of vegetation, but we can divide them roughly into the following:

(a) Brush or jungle vegetation.

(b) Open forest vegetation

(c) Semi-desert and desert vegetation

Brush Vegetation

Brush or jungle vegetation is the type of growth that we find in the semi-tropical regions of the Queensland coast and in some of the more favoured spots in the southern parts, such as Bulli Pass and Kangaroo Valley on the New South Wales coast and some parts of the Gippsland Forest in Victoria Here the soil is fairly rich and there is a good rainfall This makes the vegetation grow very rapidly. It also makes many plants commence growth This sets up a very strong competition for light among the plants because, as you know, plants need light in order to make their food Jungle plants solve the problem of obtaining sufficient light by one of four methods·

(a) By growing up very tall and straight

(b) By having divided leaves which will catch more of the light that filters through the trees

(c) By having twining stems which can grow quickly by using other plants, such as the tall trees, for support

(d) By learning to use moisture from the air instead of from the soil and so being able to grow on the branches of tall trees and get light in this way

So, in jungle, country, we get·

(a) Tall, straight trees with few branches for several feet from the base

(b) Plants like ferns, with divided leaves

(c) Climbers which, instead of using energy to produce thick, woody stems, produce long, thin ones which reach the light more quickly

(d) Tree orchids and other plants which perch on the branches of high trees So much moisture fills the air in these jungles that the soft roots of such plants are able to get all the nourishment they require from it Rock lilies are such plants

[Photo G Grant-Thomson]

A typical brush scene on Tambourine Mt, Queensland

In the jungle the trees grow fast and are commonly known in trade as softwoods Among the softwoods are the cabinet timbers, used for furniture making, and so on Some of our best softwood timbers are: **Red Cedar, Coachwood, Silky Oak, Queensland Maple,** and so on

When the early Australian settlers began to penetrate into the jungle areas they had to cut their way through dense timber Often they cut down great trees and simply left them to rot, not knowing how valuable they were Australian softwoods are especially valuable because, as you know, there is not very much of this kind of country over the whole continent

Open Forest Vegetation

Open forest vegetation is often described as eucalypt or hardwood forest It is made up of areas which are not as favored as the brush areas and in which the plants grow much less closely together The trees, therefore, have a tendency to branch much more closely to the ground, and to be more twisted than brush trees. Growing among the trees one finds a great variety of shrubs, but Australia does not have very many annuals or plants which die down every year

This open forest vegetation includes a great variety of different kinds of vegetation, such as that which covers the larger part of the east coast of Australia, much of the western coast, large areas of northern Victoria and, indeed, for our purposes, all the country which cannot properly be called brush vegetation or desert vegetation

In the open forest land we find some of our most beautiful flowers. We find many strange plants, too, plants which have learned to adapt themselves to harsh conditions of soil and climate

[Photo H T Reeves]

The dense growth in this Gippsland (Victoria) brush is by no means easy to penetrate

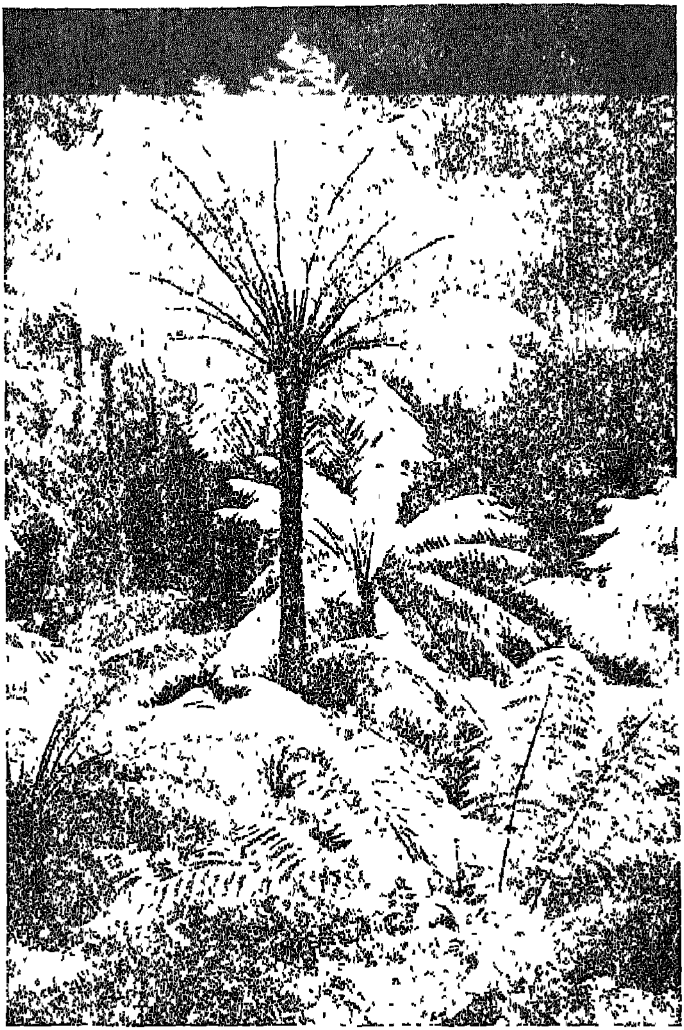
Semi-Desert Vegetation

Semi-desert vegetation is found in those parts of Australia where the rainfall and the soil are too poor for any tall trees to grow and where the growth is poor and scattered The temperature is very high and the air very dry so that there is a very high rate of evaporation In some such areas are found dwarf trees called **Mallees.** These are types of **Eucalyptus** which do not grow very high and which produce a number of stems from one root, instead of one main stem Some of them produce the most beautiful red blossoms.

Among the **Mallees** one also finds some **Wattles** or **Acacias.** You will know the names of **Mulga, Myall** and **Boree,** types of **Acacias** living in the inland parts of Australia Another type of plant typical of these regions is the **Saltbush.** There are many different types of **Saltbush,** all of them belonging to the desert and semi-desert regions and all having a high percentage of common salt in their leaves

Of course, this way of classifying our bushlands is a very rough one You can imagine that over a continent of three million square miles there will be many more kinds than the three I have spoken of But these are the three major divisions, and, of the three, by far the smallest area is taken up by the jungle plants So you can see that Australia contains a very vast area which produces open forest of hardwoods or semi-desert vegetation

A great deal of this vegetation is on hard, unsympathetic soil like that of most of our eastern coast and almost all of our west coast The soil, too, for the most part, is sandy and not very well watered Yet it produces an amazing variety of most beautiful wild flowers. As the soil is sandy in so many places the plants are easily uprooted Because of this, and



[Photo H T Reeves]

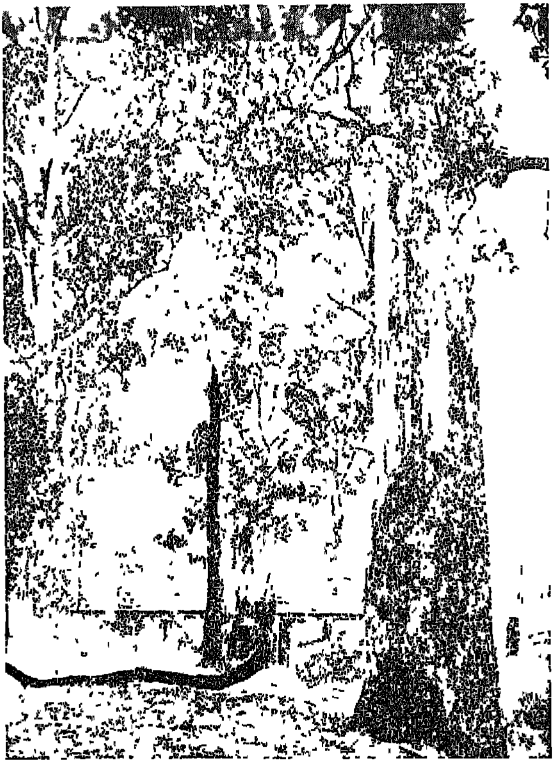
Tree ferns are typical of much of the Gippsland brush because people are thoughtless, a great many plants of some of our loveliest flowers have been destroyed It is not easy to understand how people who get pleasure from the appearance of a beautiful bush plant can be so lacking in imagination as not to see the inevitable result of these constant depredations.

In open forest in good country the trees grow tall and straight because they are reaching up to the light

In many parts of New South Wales, to my personal knowledge, areas have been completely denuded of **Boronia, Native Rose** and other lovely plants

Looking After Our Plants

Because of this tendency which people have of destroying without thought these lovely flowers, most



A coastal scene in New South Wales Tall, strong Blue Gums (Eucalyptus saligna) along a creek bed, in open forest country.

of the States of Australia have introduced some legislation for the protection of wild flowers

There is, of course, one best method of protecting all plants from unnecessary and wanton destruction That way is to educate people to understand the necessity for care, and I hope that you will all help to do this If people learned to appreciate the beauty of the bush and wanted to retain that beauty as long as they could there would be no need for protective legislation

In the meantime, however, while people are learning how to take care of their property—for the bush plants belong to all of us—there is a grave danger of considerable destruction being brought about So

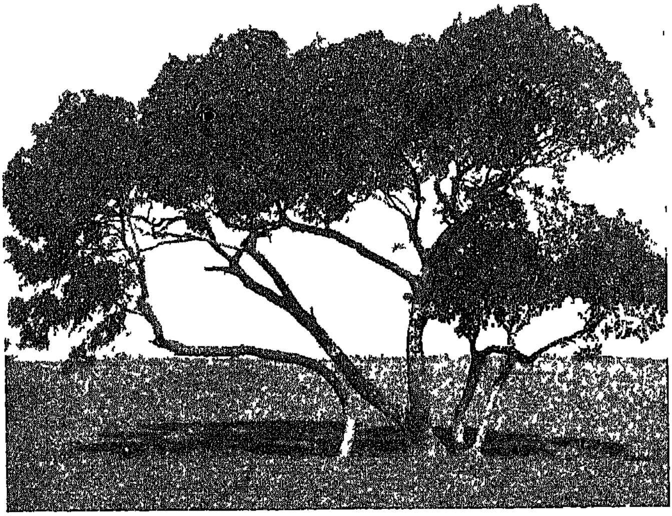
[Photo H T Reeves]

A scene in northern Victoria on the edge of the Eucalypt forest country The tree in the foreground is a Manna Gum (Eucalyptus viminalis)

Poor growth of Eucalypts on eroded, hilly country in inland New South Wales The tree in the foreground is a Narrow-leafed Ironbark (Eucalyptus crebra)

[Photo H T Reeves]

The picturesque coastal Teatree (Leptospermum laevigatum) so common on our sandy patches on the seashore protective legislation seems essential The principle of this legislation is to forbid people to pick certain plants and to punish them if they disobey the law Many bush-lovers have been trying to introduce a new law forbidding the sale of any protected flowers with the exception of Christmas Bush Now this may seem very harsh It will mean that people who have grown plants especially for sale will be prevented from selling them so as to ensure that the plants in the bush will not be taken at all While it is harsh for such growers there seems no other way of protecting the lovely flowers which rightly belong to all of us Commercial growers will still be permitted, indeed encouraged, to



[Photo Albert Morris]

A typical Mallee of the inland Note the number of stems springing from the base sell plants, but not cut flowers, so that they may well be able to turn their attention to this side of their work This should increase the number of native plants grown in gardens As surely as this happens there will be an increased regard for them and they will be much safer, for people will not destroy them as thoughtlessly as they have done in the past

You can see, then, that it is only through the real interest of its people that Australia will be able to retain much of her very beautiful and very interesting native plants We must learn to admire them in their native haunts and to deny ourselves the pleasure of having them in our homes until we feel sure that every Australian is sufficiently well educated to be trusted to cut carefully and with discrimination

Some Protected Plants

Now let me tell you something about some of the plants which are on the present protected list (1943-1947) in New South Wales.

The Boronias

All known species, including **Native Rose**, are protected Most of the Boronias grow in sandstone country and they are great favorites They have four petals, usually pink, eight stamens, and an oily or aromatic odour The most sweet-scented of all are the **Native Rose** of New South Wales, and the **Brown Boronia** of Western Australia

These plants are fairly easily grown from seed but the seed should be collected and sown while it is still green This seems rather strange, but many growers will tell you that they get most success this way. As with most natives they will grow best in a sandy soil or light loam kept slightly damp Never let the soil get quite dry, but do not overwater.

There are a great many different species of Boronia in New South Wales, something over 30

The Wax Flowers (Eriostemon)

Several of these are protected They are closely related to the Boronias, but have five petals and ten stamens There is one very interesting form cultivated which, I think, you would like to know about. It is a double flowering form of the **Blunt-leafed Wax Plant.** This is a dainty little plant fairly common in New South Wales and Victoria At one time, some years ago, two plants of this were found on the hills round Bendigo and these were different from any others The flowers were double One of these two plants was taken to a nurseryman in Melbourne He wanted to grow some more plants like it It was no good sowing seed, because the plant was a "sport" and would not have produced double flowering offspring but single flowering, so he took cuttings from the plant He got about twelve of them to grow and, when they were big enough, he took cuttings from these and went on until he had a great many plants, all with double flowers, and all from the same original "sport" In Melbourne to-day you will find many suburban gardens with this double flowering wax plant flourishing

Wax Flowers may be grown from seed in the same way as **Boronias.** Fairly green seed should be used

Christmas Bells (Blandfordia)

Christmas Bells grow in swampy areas and flower in December and January They are very beautiful with their gay red and yellow bells The bell part of the flower is made of the sepals and petals joined together, six parts in all. The flower belongs to the Lily family Ripe seeds of the **Christmas Bell** may be obtained from the triangular pod-like fruit which follows the flower They require a very sandy soil for germination and are very slow.

Christmas Bush (Ceratopetalum)

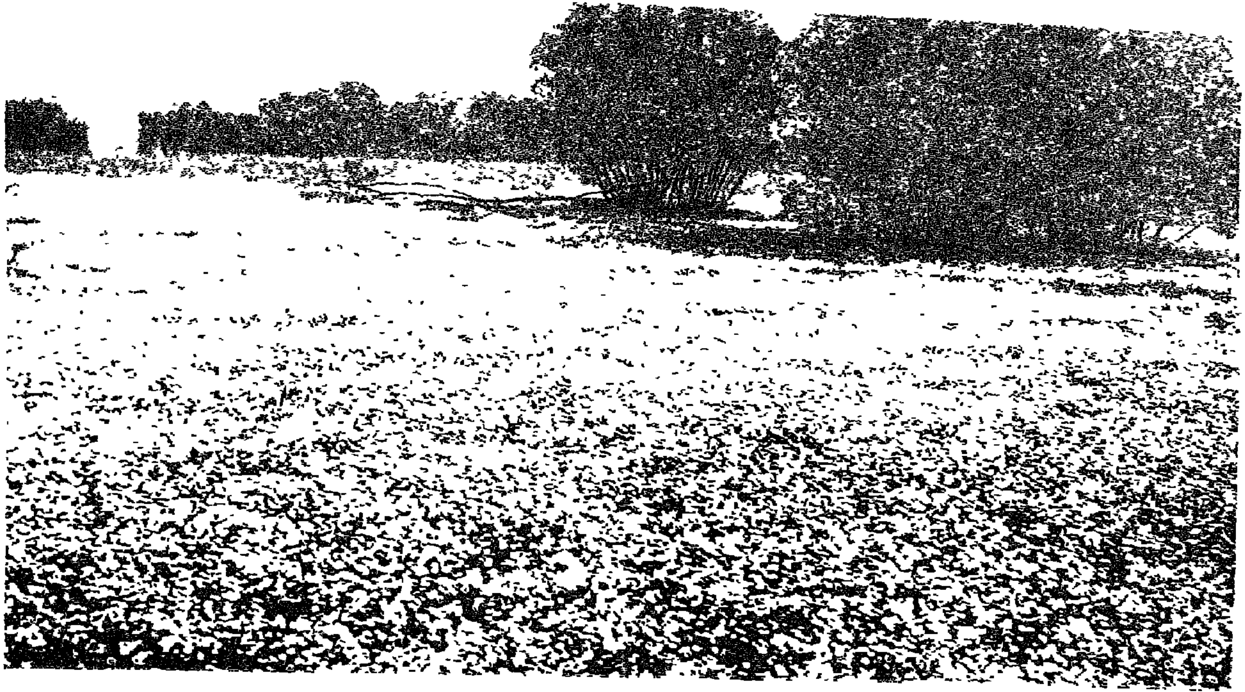
Christmas Bush of New South Wales prefers the jungle country You may be surprised to learn that the flowers of the **Christmas Bush** are small, white, and with a rather unpleasant odour, coming out in about October or early November What is commonly called the flower is the fruit or seedbox round which the petals have grown and become red This attraction in the flower is for the purpose of bringing birds who may scatter the seeds **Christmas Bush** seed does best when it is ripe but quite fresh, so if you take some of the withering "flowers" and push them into the soil they should grow They require a light loam for germination

Waratah (Telopea)

The brilliant red heads of the **Waratah** are well known indeed Waratahs like clay gullies or clay pockets in sandstone soil They are especially prolific on our Blue Mountains The head is a group of smaller individual flowers and there is a row of attractive red bracts or leaves at the base The seed pods are very handsome, bearing a number of winged seeds. These are fairly easy to germinate in a light loam You should be careful to keep the seedlings moist, but not really wet, as they often die from the damping off fungus

[The name Waratah was an aboriginal word indicating "seen from afar," and those of you who know this handsome flower in the bush will agree that it is a well-deserved name

Although it is so very handsome the Waratah would not be a good choice as a Australian national flower



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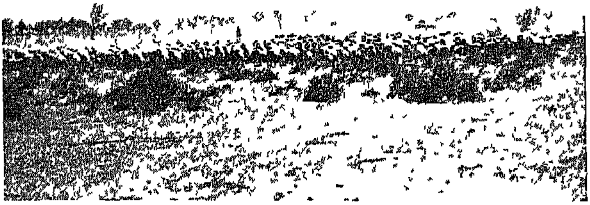
A field of daisies (*Helichrysum*) in the dry, mallee country of Northern Victoria



In the semi-desert areas sparse, bushy shrubs and undershrubs are the largest forms of plant life This is country west of Broken Hill

[Photo K Elger]

In selected patches in the far west the glorious Desert Pea (Clianthus speciosus) grows in profusion, with a mass of rich red blooms

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because of its restricted habitat or place of growth It only grows along the east coast of New South Wales and for a short distance into Queensland. People of the other States and those from inland parts of New South Wales have rarely seen it growing. Some have never seen it at all]

Flannel Flowers (Actinotus)

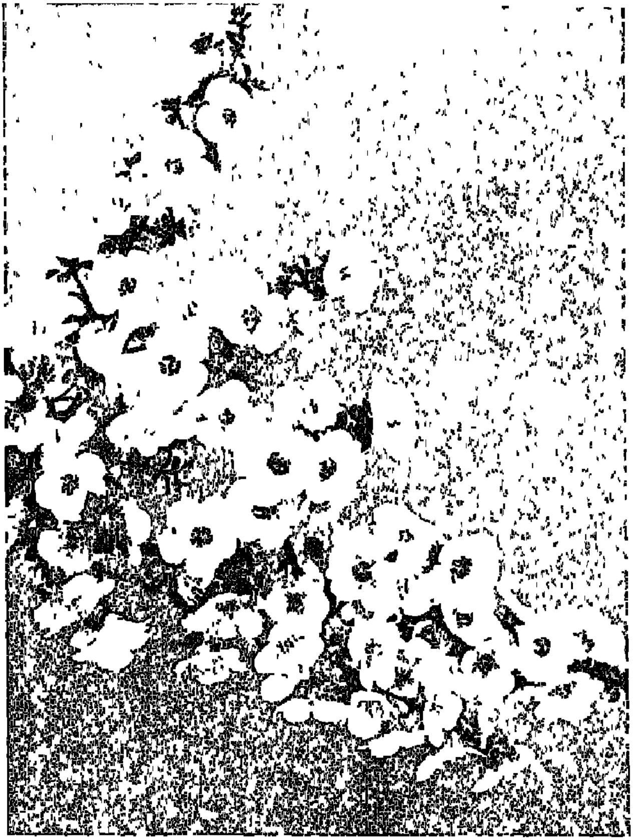
Flannel Flowers grow on hilly or rocky patches where they get very little soil but they are not easy to cultivate Each head consists of a number of tiny flowers in the centre, surrounded by those petal-like things which are really bracts They belong to the same family as parsnips, parsley, etc Seed is best germinated in very sandy soil or in pure sand kept slightly damp all the time but not wet Never let the soil get really dry or the tiny seedlings will wither even before you can see they are there

Mint Bush (Prostanthera)

Mint Bush is one of the frequenters of the better soil It belongs to the same family as the mint which provides the spearmint and peppermint of your chewing gum and sweets, and makes mint sauce, and the salvia and other sages. Most species have soft, attractive and dainty, purple, lipped flowers It can be germinated in a fairly heavy soil

Swamp Epacris (Sprengelia)

As its name implies this is a lover of the swamps and belongs to the heath family. Each tiny flower has five petals The leaves are stiff and admirably suited to the head of flowers, giving it a rather papery appearance This plant is very difficult to grow from seed. It varies in colour from a very light pink or white to a rich, deep pink.



[Photo H T Reeves]

Leptospermum flavescens, one of the common Tea-trees with white, open, five-petalled flowers, much sought after by bees

[Photo H T Reeves]

The Trigger Plant (Stylidium laricifolium) has stamens and pistil united into a column which is very sensitive to touch When the pollen is ripe the sudden shooting of the column will cause discharge of pollen on the back of the insect, causing the explosion After the pollen has been exhausted the stigma ripens and another explosion may cause it to hit an insect carrying pollen, thus effecting pollination

Bottlebrushes (Callistemons)

There are several different Bottlebrushes, but they all have red or cream, feathery flowers. The flowers are feathery because each flower has a large number of long, conspicuous stamens which form the most attractive part of the flower. The head or "bottlebrush" consists of a number of flowers produced very close together The seeds, which are very fine, will fall out of the capsules or fruits if you remove the latter from the plant. They grow fairly easily, but not very quickly, in a very light, loamy or sandy seedbed Try not to plant the very fine seeds too close together

[Photo H T Reeves]

A tree of the brush or jungle country, **Pithecolobium grandiflorum** The pods are curved and split open to reveal shiny black seeds seated on orange red cushions

Woody Pear (Xylomelum)

Woody Pear is one of our quaintest plants. The leaves are very handsome, stiff and harsh, somewhat like those of **Waratah** when they are old, but a rich, red colour when they are very young. The flowers are produced in quaint, hanging heads, and the fruit, just like a woody pear and very velvety on the outside,

[Photo H T Reeves]

A lovely Queensland plant, **Grevillea Banksii**, commonly grown in cultivation splits open to produce two yellow, winged seeds. These seeds will grow in a loamy seed bed. They take a long time to begin and the bed must not be allowed to remain too damp, for fear of the damping-off fungus

Gymea Lily (Doryanthes)

This great giant among our natives often reaches a height of twenty feet in the flower stem with long, ribbon-like leaves It loves the clay pockets of the coast

Desert Pea (Clianthus)

Those of you who know the inland will remember seeing clumps of this remarkable and beautiful pea

[Photo H T Reeves]

The blossoms of **Angophora lanceolata**, the common Sydney Red Gum, are very like Eucalypt blossom But they do not have a cap which lifts off like the latter and the calyx and fruit cases are distinctly ribbed, as this photograph shows growing in the most parched areas. The stem scrambles along the ground, producing silvery grey, feathery leaves and great heads of scarlet pea flowers. It is a magnificent sight to see it in bloom.

Some of our Non-Protected Plants

There are, of course, many more plants which do not have this protection offered them and which include some very beautiful plants It is a good thing to remember that all bush plants should be treated with the greatest of care and never pulled carelessly or thoughtlessly There is a great deal of pleasure to be derived from taking a walk in the bush and enjoying the flowers as you pass them and leaving

[Photo H T Reeves]

One of the largest of the Eucalypt flowers, a Western Australian Red Flowering species, Eucalyptus macrocarpa Note the cap or operculum lifting off to reveal the attractive stamens them for others to see afterwards. You can store up pictures in your mind which will be far more lovely and far more lasting than the most exquisitely arranged vase of cut blooms.

We are not talking about classifying plants or dividing them into groups in this book, but you will realise that it soon becomes necessary to do this for the sake of convenience. When you go out into the bush examine the flowers carefully and try to see which ones you would group together as being somewhat like one another. Don't put them together because they look alike at a careless glance, but because of the number or arrangements of their petals and other flower parts Pay little attention to colour It is not important in classifying plants, but the parts of the flower and the kind of fruits are. You will, perhaps, be astonished at your own cleverness if you begin examining flowers and fruits and can see which ones are closely related and which ones are not But let us leave it at that for the present.

UNIT 8

What Sort of Animals does Australia Produce?

You have read, in the last unit, about Australian plants and how interesting and beautiful they are. In this unit we are going to see what we can find out about Australian animals and particularly about Australian mammals A mammal is a furred animal which suckles its young, that is, the mother feeds her young on milk produced by her own body. Most mammals are land animals, but a few of them, like whales and seals and dolphins, live in the sea. Those of you who remember watching the funny seals at the Zoo will remember how they looked as they lurched clumsily out of the water to get food They are not covered with scales, like a fish, but with a hair which lies smoothly along the body when it is wet Water mammals do not need very heavy coats of hair like some of the land mammals which have to protect themselves against changes of climate Bears and cats, some dogs, squirrels and many other mammals have very thick coats Humans are mammals in which the hairy covering of the body has almost disappeared, and so men, except those who live in the hotter parts of the earth, find it necessary to clothe themselves

Now most mammals, as you know, are viviparous or live-bearing animals which do not lay eggs but which produce live babies directly from their bodies

Who ever thought of a calf or a foal or a guinea pig hatching from an egg? Of course they don't! They are produced directly from the body of the mother

In Australia the majority of the mammals also produce live young, but they are in such an immature state that they are still dependent on the mother for a long time after birth Those of you who have seen a horse or a cow born will have been amazed at the rapidity with which the new-born baby is able to support itself on its very wobbly legs and soon to run and frisk about The foal or calf is fed with the mother's milk for some weeks after birth, but they will supplement this food with grass of their own finding If a calf is weaned it may become independent of milk in its diet in a very short time

But when a baby kangaroo or a baby wombat is born it is a long time before it is independent In the first place, it is very tiny, much less than an inch in length, as a rule Then it is naked and would soon die of exposure if it were not looked after. As soon as it is born it makes its way by scrambling across the mother's body into a specially made pouch called a **marsupium** on the underside Beneath this pouch or **marsupium** are the **mammary glands** or teats which produce the milk The tiny, newly-born creature, or creatures, move into the pouch and attach themselves onto the mother's teats There they remain, just sucking, sucking, sucking, and growing, growing, growing, and becoming covered with fur Then, at last, the little animals are quite well able to look after themselves and can come out of the pouch. Sometimes after they are well able to look after themselves they still use the pouch for protection and you will often see a fully furred "joey" kangaroo peeping out of its mother's pouch

Because of the presence of this pouch or **marsupium** the pouched mammals are called **marsupials.** Nearly all the native mammals of Australia, like the **Kangaroos** and **Wallabies, Koala** (ko'la), **Wombats, Bandicoots, Tasmanian Devil, Tasmanian Wolf, Possums,** and so on, are **marsupials.** There are no **marsupials** native to any other part of the world except a few **Opossums** in America The Australian animal, the **Possum,** was so called from its resemblance to the true opossum of America, but it is less confusing if we use the word Possum for the Australian species

Animals found commonly in Australia and which produce live young in a fairly mature state such as **Rabbits, Foxes, Mice** and **Rats,** have been brought to the continent either accidentally or by intent

There is, however, another small group of Australian mammals which are very interesting These are the egg-laying mammals, the **Platypus** (or **Water Mole** as it is sometimes called) and the **Echidna** or **Spiny Ant Eater.** These are mammals because they are fur bearing (the **Echidna** has quills also for protection) and suckle their young They are the only known mammals to lay eggs The eggs are rather different, though, from those of egg-laying animals like birds and many snakes and lizards You know, of course, that if an egg is fertile it has the beginning of a young animal inside it If you break open the fertile egg of a hen you will find a small, reddish spot on the yolk This is the part which would develop into a chicken if the egg were warmed sufficiently The rest of the egg, the yolk and the white and the shell, serve as food and as protection In a bird the egg is deposited very soon after it is fertilised and the young will develop slowly outside the body of the mother But, in the **Platypus,** the young animal inside the egg is much further developed when the egg leaves the body of the mother More than this the young **Platypus** is hatched long before it is really fully developed. If you have ever watched a chicken peck its way out of an egg, or a lizard emerge from its egg, you will be amazed at the rapidity with which the young animal assumes responsibility for itself The chicken starts pecking for food as soon as it is dry and the baby lizard will stick out its tongue to catch a passing fly within a few minutes of birth But not so with the baby **Platypus.** It is helpless for some weeks after birth, having to be fed and cared for by its mother She suckles it and provides it with solid food before it is able to go hunting for itself

These two interesting groups of Australian mammals, the **marsupials** (animals which carry their young in a pouch) and the **monotremes** (animals which have only one opening for getting rid of excreta or waste matter from the body) form connecting links between the higher mammals and the true egg-laying animals You can see from the little I have told you that the difference between egg-laying or oviparous animals and live-bearing or viviparous animals is not so very great after all A bird lays an egg which is in a very early stage of development; a platypus lays an egg which is in a more advanced stage of development and hatches earlier, the marsupials do not lay eggs but hatch these eggs within their own bodies and release them while the young are still very immature, the more advanced live-bearing or placental mammals, like cows and horses, hatch their young and care for them within their own bodies until they are in a fairly late stage of development

Why Does Australia Have Such Queer Mammals?

Eggs are very good food, as you all know The reason why they are such good food is that they have to contain concentrated food to supply the developing young So eggs are much sought after by predatory or preying animals It is safer, in many ways, to produce live young than to produce eggs If the young are born in a fairly mature state, like foals and calves, it is best of all, for they can defend themselves against their enemies. An egg certainly cannot do this A baby **Possum** or **Koala** (ko'la) cannot do this either We, therefore, regard placental mammals which retain the young within the body until they are fairly mature as more advanced than either egg-laying mammals or marsupials (pouched mammals)

Now, a long, long time ago there were no placental mammals at all And, of course, there were no humans The most highly-developed animals in the world were the egg-laying mammals and the pouch-bearing mammals At that time Australia was not a continent isolated in a great sea, but was joined on to other countries By some method Australia became separated and occupied a position close to her present one In the northern continents conditions for producing animals which kept their young within their bodies until they were more advanced than those of the marsupials came about These better equipped animals preyed on the egg-laying animals and the marsupials until the latter gradually disappeared because they were not so well equipped to look after themselves Thus it was that, in the northern countries, with one or two exceptions in America, the marsupials all disappeared But we know that they used to live there in earlier ages for remains of their bodies have been found as fossils in the earlier rocks.

In Australia, now cut off from northern lands by a vast mass of water, conditions for producing placental mammals did not appear and so the marsupials had no competitors.

Do We Need to Protect Our Mammals?

The mammals of Australia are very attractive little creatures, for the most part, and very interesting. Very few of them are seriously destructive to things that matter to humans The majority of them are vegetable-eating animals and, not having to fight for their food, are not aggressive. On the other hand, the clearing of the forests and the opening up of land has deprived many of these animals of their natural shelter and food and, in many places where they were once common, they have been almost, or completely, wiped out Most **marsupials** do not make happy pets for they like the freedom of the forest in which to wander in search of their food. Vegetable-eating animals frequently find that necessary and it is especially so in a vast and dry country like Australia.

How Can We Protect Our Animals?

There are many kinds of animals which need protection as well as the mammals, but we will speak about the latter first It is necessary to ensure that the animals are not taken and killed for the sake of their fur, many of which are very good quality indeed. We must provide sanctuaries where they can breed. This is not as easy as it would sometimes seem. On Phillip Island, in Western Port, near Port Melbourne, for instance, is a koala sanctuary. But there, if conditions are good, they breed so fast that they would starve one another out if batches of them were not removed to the mainland from time to time. Again, kangaroos and wallabies can do great damage to crops and to farmlands if they are present in large numbers. In the interests of man it sometimes becomes necessary to reduce their number.

In New South Wales the Birds and Animals' Protection Act protects all animals (including birds) except a list of harmful animals which is appended.

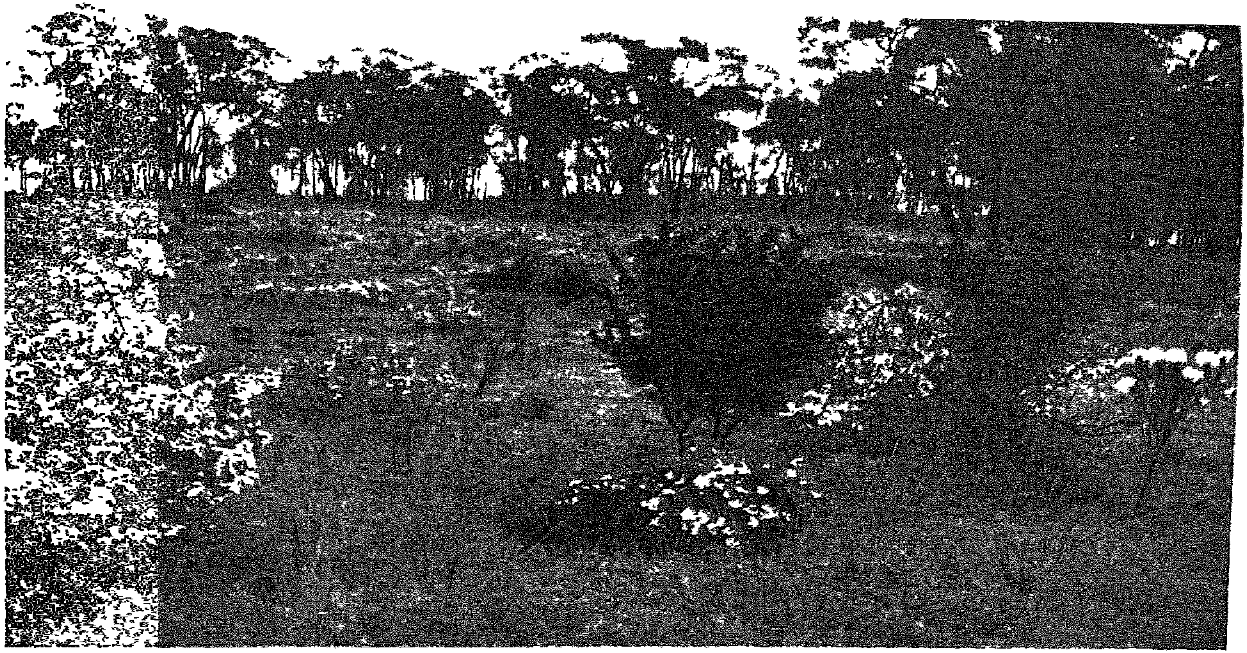
At the same time the Act provides for a close season for any of these animals should conditions warrant it and may provide an open season for animals which are ordinarily protected by the law.

You will see that such an act as this one is not easily administered. It would be more satisfactory if open seasons were never declared, but animals causing destruction or interfering with human welfare were destroyed by Government order in the most humane way possible Under the existing law there is a great temptation for people who think the sport (so-called) of killing animals is highly entertaining to take advantage of it

Sanctuaries which are to be of real value in the preservation of our fauna need to be closed sanctuaries, at least for a large part of the time, to leave the animals free from molestation or interference Large parks, daily visited by large numbers of people, have proved in the past to be unsatisfactory as far as increasing the number of mammals, such as koalas and kangaroos, kept in captivity, even though the areas and food supply are adequate.

What Can We Do?

It is most important that we should do all we can to preserve the native animals of our continent While it is a good thing to have laws for protection we do not want to preserve our animals by punishing people who destroy them We need to educate the people to want to preserve them But it is no use wanting to do something without knowing how to do it. If we want to preserve our native animals we need to know something about them, about their habits and about their likes and dislikes So we should do this, first of all—learn all we can about our interesting animals, including our birds, so that all Australians will have them, many generations of Australians after us



Open forest country near Bendigo Victoria Such country is prolific in bright flowering shrubs In this study is shown the Bendigo Wax Flower (Eriostemon), on the extreme left a yellow Guinea flower (Hibbertia) in the centre foreground with a plant of the Bitter Pea (Daviesia) immediately behind it and a plant of the Downy Rice Flower (Pimelea) on the extreme left

[Photo
H T Reeves]

INDEX

[Pages with Illustrations shown in bold figures]

A

Acacias **59, 64, 66,** 167
Actinotus **61, 64, 66, 78,** 179
Adverse conditions of environment 30
Air and plants 25
Air and seeds 113
Air for aquarium 82, **98**
  for breathing 67, **83, 84, 85, 87**
  for food making **104**
  for respiration **83, 84, 85,** 86
Albizzia leaves **63**
Alighting platform 125
Alternating colour in camouflage 46
Ammonium sulphate 23
Ancestors of fungi 24 25
Anemones 16, 17, 18, 20
Angophora fruit **132**
Angophora lanceolata **183**
Animal food **20, 21,** 30
Animal protection 30 et seq 190-192
Animal sanctuaries 191, 192
Animals as seed scatterers 133
Animals and fruits 129, 133
  and plants 16 et seq
  carnivorous 19, 20-21
  dependent on plants 16 19 **24,** 25
  flesh-eating 19, 20 21
  herbivorous 19 **20**
  in aquariums 107
  plant-eating 19 **20**
  young 134
Anteater, Spiny **55,** 188
Apple **132**
Apple pinara 150
Aquarium plants 107
Aquariums **98,** 106-108, 160-161
Aquatic animals 80-83
Australian animals 186-192
  mammals 186-192
  plants 162 et seq
  vegetation 162 et seq

B

Baby plant **113**
Bandicoots 135, 188
Banksia **64, 66**
Banksia moth 151
Bean butterfly 153
Bee pollination 125-127
Bees and honey 126
  and pollen 126
Beetle cockchafer 40, 51, 53
Beetles, diving 35
  water 35, 50, 53 161
Bird pollination 123, **126**
Birds and flowers 123, 126
  community life 42
  food 19
  warning cry 42
Bird visited flowers 123 **126**
Blandfordia 175
Blood in respiration 86
Blue fanny butterfly 153
Blue Gum moth 152
Blue Gums **170**
Blue tongue lizard 15, 51 160
Blunt leafed wax flower 175
Boatmen water 34 50 53
Boggy soil 23
Bottlebrush 181
Boree 167
Boronia 170, 174-175
  Brown 174
Bossiaea **59,** 61, **64, 66**
Bracket fungus **24**
Breathing 73-74
Breathing holes of caterpillar **83**
Breathing of aquatic animals 80-81
  of boy **87**
  of caterpillar 83
  of earthworm **85**
  of fish **80,** 87
  of frog **84**
  of mammals 78 **87**
  of mosquito 81, **82**
  of plants 77, **87,** 106
  of snails **38, 79**
Breathing pore of butterfly **83,** 84
  of caterpillar **83**
  of earthworm **85,** 86
  of insect **83,** 84
  of moth 84
  of frog **84**
  of tadpole 138
Breathing roots **88**
Broad bean germination 114
Broad-tailed gecko **47**
Bronchial tubes 86
Brown looper caterpillar, **37,** 50 **53, 83**
Brush Gippsland **164,** 165, **166,** 167 **168**
  vegetation 162-166

INDEX

[Pages with Illustrations shown in bold figures]

Bugs 84
water 34
Burning and carbon dioxide 103
and oxygen **69, 70**
Bushlands, classification 167
preservation 168-174
Butterfly, bean 153
blue fanny 153
cabbage white **13**, 153
food **20**, 83
caper **149**, 153
eggs 140, 144
imperial white 153
monarch 140-148, **143, 145,**
146, 147, 148, 151, 153, 194
orange 152
pollination 124, 125
veins 83-84
wanderer 140-148, **143, 145,**
146, 147, 148, 151
Butterflies 50, 83, 140-153

C

Cabbage moth 152
white butterfly **13**, 153
Caddis fly larva 32, 51
worm 51
Callistemon 181
Camouflage 34, 37, 44, 45-49
in caterpillar **49**
in gecko **47**
in leaf insect **48, 49**
Caper white butterfly **149**, 153
Capsule of poppy **28**, 133
Carbon in starch **75**
in sugar **75**
Carbon dioxide 75, 76
Carbon dioxide and burning 103
and food making 103
and plants
76, 102, 103-105, **104**
collection 102
for breathing 75
in expired air 75, 76
in respiration 86-88, **87**
preparation **101**, 102
solubility 102
test 102
Carnivorous animals 19, **20-21**
plants **22, 23**
Carrot **90**
Casemoth 43, **44**, 51, 53, 150, 151
protection 43
Caterpillar as food 19
brown looper 37, 50, **53, 83**
Cabbage white **13**, 153
caper butterfly **149**, 152
casemoth 43, 44, 51, 53
cupmoth **35-36**, 50, 53
food 108, 140
gum tree 44
hairy **36**
looper 37, 50, **53, 83**
menacing **45**
monarch
39, 50, 140-141, **143, 145**
Nola **49**
Pinara 44, 51, 53
Tiger moth **36**, 50
wanderer **39**, 50, 53,
140-141, **143, 145**
woolly bear **36**
Cats, domestic 19
native 19
Cauliflower **90**
Caustic potash 104, 105
Cedar, red 165
Ceratopetalum 176
Cereals 91
Characteristics of living things 15
Chili saltpetre 23
Chlorophyll 19, 22, 24, 26
Chlorophyll and starch making 99
removal 97
Christmas bells 175
Christmas bush 173 176
Cladodes **59**
Classifying plants 185
Clianthus speciosus **177**, 183
Climbing to light 58
Coats of mammals 186
Cobæa flower 116, **118, 119**, **120**, 121,122
pollination 119-122
Cobblers' Pegs 131, 133
Cockchafer beetle **40**, 51, 53
Cocoons **145, 146, 147**
Collecting oxygen 67, **69**
Community life of birds 41
Competition in nature 30
Conesticks **132**
Conditions of environment 31
Corals **16, 17, 18**, 20
Cow **20**
Crickets' eggs 144

INDEX

[Pages with Illustrations shown in bold figures]

Crystals, growth of 11-12
Cultivation of native plants 173-174
Cupmoth caterpillar **35, 36,** 50, **53**
Cupmoth mottled 150
  painted 150

D

Darala moth 152
Death of seeds 29
Degenerate plants 24
Desert pea **177,** 183
Differences in living and non-living things 7
Differences in plants and animals 18
Digestive juices 22
Dillwynia **58, 64, 66**
Dingoes 19, **21**
Diving beetle 35
Dolichos 129, 133
Dominant winds 62
Doryanthes 183
Dragon fly larvae 32, 156, **157,** 161
  nymph **157**
Dragon fly life history 156, 158
Dragon, horned **54**
Dried fruit moth 152
Drosera 22, **23**
Dutchman's Pipe **132**

E

Earthstar **24**
Earthworm **85,** 108
Echidna **55,** 188
Eggs and Bacon **58, 59,** 61, **64, 66**
Egg hatching **33,** 140
Eggs of butterfly 35, 144
  of cricket 144
  of dragon fly 156
  of frog 32, 136 144
  of garden snail 144
  of grasshopper 144, **161**
  of ground lizard 144
  of lacewing 144
  of lizard 144
  of long-horned grasshopper 144, **161**
  of mantis 144
  of mosquito **82, 155**
  of moths 35
  of pond snails 144
Eggs of robin 144
  of sawfly 144
  of shark 144
  of snail 144
  of spider 144
  of toad 32, **33,** 144
Emergence of butterfly 142, **147**
  mosquito **155**
  tadpoles **33**
Emperor gum moth 142, 153
Energy 12-13
  and fever 74
  and heat 14
  for growth 74
  for jumping 73
  for running 73, 74
  for skipping 74
  for warmth 74
  in food 89
  of sunlight 73
Environment 31
Epacris, swamp 178
Eriostemon 175
Eucalypt forest in Victoria **171**
Eucalypt forest vegetation 165, **169**
Eucalypts on poor soil **172**
Eucalyptus crebra **172**
  macrocarpa **184**
  saligna **170**
  viminalis **171**
Excursion 33 et seq

F

Faggot case moth 150
Fairy rings **27**
Feathery leaves of wattles **59-60**
Feeding of tadpoles 138
Ferns **64, 66, 168**
Fertile seed 29
Fertilisation in the frog 136
Fever and energy 74
Fine leaves for protection 62
First leaves 114
  root 114
  shoot 114
Fish breathing 80
Fish in aquariums 108
Fish respiration **80**
Fivecorners 131
Flannel Flowers 56, **61,** 63, **64, 66,** 178

INDEX

[Pages with Illustrations shown in bold figures]

Flattened leaves 60, 62, **64**, 65, **66**
in wattle **59**, 60
Flattened stems **59**, 62, **64**, 65, **66**
in Bossiæa **65**, 61
Fleetness of foot 20, 45
Flesh-eating animals 19, 20-**21**
Flour as a plant product 89, 91
Flower buds 17
Flower of Cobæa 116, 118
Flower structure 116-118
Food and energy 74
Food making and carbon dioxide 103
and plants 106
from plants **90**
Food of anemone 20
of animals 30, 108
of birds 19
of butterflies 108
of caterpillars 108, 140
of corals 20
of earthworm 108
of frogs 108 138
of fungi 26
of mosquitoes 108
of moths 108
of plants 16 19, 25, 30, 89 et seq
of sponges 20
French bean germination 114, **115**
Frog 84,-85, 135-139, **136**
fertilisation 136
life history 10, 32, 33, 135-139
spawn 32, **136**, 137, 144
Frog's eggs 32, 136, 137, 141
Fruit is food for birds 19
Fruits 128
and animals 129
of Angophora **132**
of apple **132**
of conesticks **132**
of Dutchman's pipe **132**
of geebungs **132**
of gum **132**
of Geranium **13**
of Hakea **129**, **130**, 131, 133
of mistletoe 129, **132**, 133
of mountain devil **130**
of native currant **130**, 133
of orange **132**
of sunflower **129**
of teatree **130**
of thistle 129, 133
of thornapple **130**
Fruits of wattle **130**, 131
of woody pear **130**, 131
Fruits, scattering 128-133
Fungi **24**, 25, **26**, **27**
Fungus, bracket **24**
Furry coverings for protection 56

G

Garden snails' eggs 144
Gases liberated by plants 106
Geaster 24
Gecko, broadtailed **47**
Geebungs **132**
Germinating seeds **77**
Germination 114-116, **115**
Gill flaps 80, **81**
slits 138
Gills 80 81
of tadpole 138
Gippsland brush country **164**, **168**
Goldfinches 41, 50, 68
Grasshopper **161**
Green plant 16, **94**
Grevillea Banksii 182
Groundberries 131
Ground lizards' eggs 144
Ground plover 43
Growth 9, 12
of crystals 11-12
of living things 12
of pollen 128
Guinea pigs 160
Gums **170**, **171**, **172**, **184**
Gum emperor moth 142, 153
fruits 128-133 **130**, **132**
lemon-scented **57**, 63, **64**, **66**
tree caterpillar 44
Gymea lily 183

H

Hairs of caterpillar 36
Hakea **129**, **130**, 131, 133
Hand pollination 119-120
Hard leaves for protection 62
Hardy animals 31
plants 31
Hardwood forest vegetation 165
Hatching eggs 33 140
Heat and energy 14
Herbivorous animals 19, 20

INDEX

[Pages with Illustrations shown in bold figures]

Hibiscus 123
Honey 123
as food 19
Horned dragon **54**

I

Imago of dragon fly **157**
mosquito **82, 154, 155**
Imperial white butterfly 153
Insect, leaf **49**
pollination 121-127
Insects as food for birds 19
Iodine test 93, 95, **96**, 99
Ironbark, narrow-leafed **172**

J

Jungle 163-165
vegetation 162-165

K

Kangaroos 18, 135, 187, 188
Keeping animals 158-161
aquarium animals 161
guinea pigs 160
lizards 160
Kennedya **64, 66**
Koalas 18, 135, 188, 190

L

Lacewings' eggs 144
Larvae of caddis fly 32 51
of dragon fly
32, 156-158, **157**, 161
of looper caterpillar
37, 50, 53, **83**
of mayfly 32
of mosquito
82, 108, 154, **155**, 156
of water beetle 32, 161
Leaf casemoth 150
insect **49**
Leaves and light 93-97 **96**
Albizzia **63**
first 114
flattened **59**, 60, 62, **64**, 65, **66**
seed 113
sleep movements **63**
Lemon-scented gum **57**, 63, **64, 66**
Leptospermum flavescens **179**
lævigatum **172**
Lictor casemoth 150
Life history of dragonfly 156-158, **157**
of frog 10, 135-139
of monarch butterfly 140-145
of mosquito
82, 154-156, **155**
of toad 10, 33
of wanderer butterfly 140-145
in a pool 34
Light and plants 93-95 **94**, 106
and roots **117**
and seeds 114
and shoots **117**
and starch making 99
Limewater test 102
Living and non-living things **7**
things and carbon dioxide **77, 79**
things and oxygen
12, 14, 67, 71 74, **87**
things, characteristics 15
things, growth **10**, 12
movement **8**
respiration 77-88, **79**
tissue 9
tissue repair 11
Lizards 45, 51, 53 160
eggs 141
Looper caterpillars **37**, 50, 53, **83**
Long-horned grasshopper 161
Looking after plants 170-174
Loss of water in plants 58
Lungs 86-88
of frogs 84-85
of mammals 78 86-88

M

Maize 91
Malaria 155-156
Mallee 167, **173**
Mammals **134**, 135, 186-190
Australian 186
breathing 187, 188
coats 186
egg laying 188, 189
introduced 188
lungs 78, 80, 86-88

INDEX

[Pages with Illustrations shown in bold figures]

Mammals, oviparous 189
- placental 189-190
- respiration 78, 80
- viviparous 186, 189
- water 186
- young 187-188

Mangrove roots **88**

Manna gums 171

Mantis **48**
- camouflage 48
- eggs 144

Marsupials **134**, 135, 187-189
- young 187-188

Marsupium 135, 187

Masking leaves **96**

May fly larvæ **32**

Mercuric oxide 67, 69

Milk glands 135

Mineral salts from soil 59

Mint bush 178

Mistletoe fruit 129, **132**, 133

Moisture and plants **20**

Mole, water 188

Moloch **54**

Monarch butterfly 140-145, **142**, **143**, 148, 153
- caterpillar **39**, 50, 140, 142 **143**, 145
- pupa 39, 50, 140, 141, 142 **145**, **146**

Monotremes 189

Mosquitoes **82**, 108-109, 154, **155**, 156
- emergence **155**
- eggs **82**, 154, **155**
- food 108
- imago **82**, 154, **155**
- larvæ **81**, 154, **155**
- life history **82**, 154-**155**
- pupæ **82**, 154, **155**
- tumblers **82**, 83, 108, 154, **155**
- wrigglers **82**, 83, 108, 154, **155**

Moth emperor gum 142, 153
- mottled cup 150
- painted cup 150

Moths 50, 53, 84, 140, 150-153
- as food 108
- Banksia 151
- Bluegum 152
- Cabbage 152
- Darala 152
- dried fruit moth 151

Moths, emperor gum 142, 153
- eggs 35
- orange 151
- pollination 124
- processionary 151
- silver striped vine 151
- tomato 152
- vine 151
- wattle goat 152

Mountain devil 54, **130**

Mouth of tadpole 139

Movements of living things **8**
- of water 58-59
- spontaneous 8
- towards light 8

Mulga 167

Murray River tortoise **54**
- turtle **54**

Mushrooms **24**

Myall 167

N

Narrow-leafed ironbark 172

National flower 176 178

Native bear 18, 135, 188 190
- cats 19
- currant **130**
- plants cultivated 173-174
- rose 170, 174

Nectar 19, 22, 123, 124, 126

Nitrogen 23
- as food 22
- in proteins 23
- in soils 23

Nola caterpillar **49**

Non-living and living things **7**

Non-protected plants 184-185

Nymph of dragon fly 32, 156, **157**, 158

O

Oil for protection 57
- glands 57

Open forest country **169**
- vegetation 165

Operculum 184

Opossums 188

Orange butterfly 152
- moth 151

INDEX

[Pages with Illustrations shown in bold figures]

- Oxygen 14, 74
  - and breathing 71, 77
  - and burning **70**
  - and energy 73
  - and living things **87**
  - collection 67, **68**, **69**
  - for energy 14
  - for living things 67, 69 71
    - marine life 82
    - respiration 86
  - from plants 99, **100**
  - in air 67, 71, **72**
    - water 80, 82 **98**
  - preparation 67, **68**

P

- Painted cup moth 160
- Parasites 23
- Parental instinct **42**
- Peanuts **90**
- Pests 31
- Petrophila **132**
- Phyllodes 59, 60, 62, **64**, 65, **66**
  - of wattle **59**, 60
- Pinara, apple 150
- Pinara caterpillar 44, 51, 53, 150
- Pinara gum moth **150**
- Pitcher plant 22
- Pithecolobium grandiflorum **181**
- Plant-eating animals 19, **20**
- Plant food 16, 91 et seq
  - products 89, **90**, 91, 92
  - protection 28 et seq , 56 et seq
- Plants and animals 16, 17, 18
  - and air 25
  - and carbon dioxide 76, 102, **104**, 105
  - and energy 74
  - and food 25
  - and food making **94** et seq , 97, 106
  - and light 25, 93, **96**
  - and oxygen **100**
  - and respiration **77**, 99, 100, **106**
  - as food **90**
  - Australian 162 et seq
  - brush 163
  - degenerate 23-24
  - dependent on light 20
    - on moisture 20
  - in aquariums 107
  - in darkness **94**
- Plants in sunlight **96**, 99
  - swimming 17
- Plover ground 43
- Platypus 188-189
- Poisonous spider 41
- Pollen 118, 121, 127, 128
  - grains and seeds 122, 128
- Pollination 118, 121-128, **124**
  - bee 126 127
  - bird 123 **126**
  - butterfly 124, **125**
  - diagram **124**, **127**
  - hand **118**, **119**, **120**, **121**
  - insect 123-126
  - moth 124
  - of Cobæa 119, **120**, **121**
  - wind 121
- Pond snails' eggs 144
- Poppy capsule **28**, 133
  - plant **29**
  - seed box **28**
- Port Jackson shark's egg 144
- Possum **52**, **134**, 135, 188, 190
  - shorteared **52**, **134**
- Potatoes **90**
- Potassium chlorate 67, 69
- Preparation of carbon dioxide **101**, **103**
- Preparation of oxygen 67, **68**
- Preservation by education 171
  - by legislation 173
  - of animals 191
  - of Australian animals 191, 192
  - of beetle 40
  - of bushlands 169
  - of mammals 191
  - of plants 61
  - of spider 41
  - of snails **38**
  - of wildflowers 169
- Processionary moths 151
- Prostanthera 178
- Protection against cold 31, **64**, **66**
  - dominant winds 57, **62**, **64**, **66**
  - drought 58, **64**, **66**
  - drowning 35
  - drying up 62, **64**, **66**
  - dryness 31, **64**, **66**
  - evaporation 62, **64**, **66**
  - excessive rain 81

INDEX

[Pages with Illustrations shown in bold figures.]

Protection against extreme dryness 31, **64, 66**
    hailstones 31
    hot drying winds 58, **64, 66**
    heat 31, **64, 66**
    poor light **64,** 65, **66**
  by camouflage 45, **47, 48**
  by fleetness 45
  by fine leaves **58,** 62, **64, 66**
  by hairs **61, 64, 66**
  by hard leaves 62, **64, 66**
  by oil 62 **64, 66**
  by spines **60,** 63, **64, 66**
  from high evaporation **64,** 65 **66**
  of animals 50-55
  of mantis **46,** 48
  of monarch **39,** 42, 50
  of plants 56-66, **64, 66**
  of possums **52**
  of rabbits 41, **45, 46,** 51
  of snails **38,** 39
  of tortoise **54**
  of turtle **54**
  of wanderer **39,** 42, 50
  of young by birds 42, **43**
Pupæ of mosquito **82, 155**
Pupal case of caper white butterfly 154, **155**
    monarch butterfly **39,** 50, 140-142, **145, 146**
    wanderer butterfly **39,** 50 141-142, **145, 146**
Protective shell of snail **38**

Q

Queensland Maple 165

R

Rabbits 19, 45, **46,** 51,53
Radicle 114
Red back spider 40, 41, 42, 50 53
    female 40
    male 40
Red Cedar 165
Red Gum 183
Release of energy 73
Removal of chlorophyll 97
Repair of living tissue 9
Reproduction **13,** 14, 15, 110 et seq
Respiration 73-86, **77, 78, 79**
    in aquatic animals 80-84
    in fish **80, 87**
    in mammals 78, **87**
    in mosquitoes 81, **82**
    in plants **77, 87,** 106
    in snails **38, 79**
    in tadpoles 138
Ribbed case moth 151
Rice 91
Robin's eggs 144
Roots and light **117**
Root first 114
    hairs 116
    young 113

S

Saltbush 167
Sanctuaries, animal 191, 192
Saunders' case moth 150
Scattering of fruits 128-129, 133
    of seeds 131, 133
Sea anemone 16, 17, **18,** 20
Seals 186
Seed box 118
    leaves 113
    pods 116
Seed is alive 111
    scattering 130, 131, **132,** 133
Seeds 19 28
    and air 113-114
    and light 113
    and moisture **112**
    in reproduction **111**
    of Angophora **132**
    of apple **132**
    of Aristolochia **132**
    of Cobblers pegs 131, 133
    of conesticks **132**
    of Datura **130**
    of Dolichos 131, 133
    of Dutchman's pipe **132**
    of fivecorner 131 133
    of geebung **132**
    of groundberry 131
    of gum **132**
    of Hakea **129, 130,** 131, 133
    of Lambertia **130**
    of Leptomeria **130**
    of Loranthus **132**

INDEX

[Pages with Illustrations shown in bold figures]

Seeds of mistletoe **132**, 133
  of mountain devil **130**
  of native currant **130**
  of orange **132**, 133
  of Paspalum 133
  of Petrophila **132**
  of poppy 131
  of tea tree **130**
  of thistle 133
  of thornapple **130**
  of wattle **130**, 131
  of woody pear **130**, 131
  of Xylomelum **130**
    structure 111-112, **113**
Semi-desert vegetation 167, **177**
Setting up aquarium 106
Shamming, cockchafer **40**
Sharks' eggs 144
She-oaks **62, 64, 66**
Shell of snail **38**
  of tortoise **54**
  of turtle **54**
Shoot and light **117**
Silkworms 142
Silky Oak 165
Silver striped vine moth 151
Skin of frog 85
Sleep position of leaves **63**
Smothering fire 70
Snails 37, **38**, 50, 53
Snails and carbon dioxide **79**
Snails' eggs 141
  protection **38**
  respiration **79**
Soils poor in nitrogen 23
Solubility of carbon dioxide 102
    starch **92**
    sugar **92**
Spawn of toad 32, **33, 136**
Spider, poisonous **41**
  redback **41**, 50, 53
Spiderweb **42, 56**
Spiny Anteater **55**, 188
Sponges 16, **17, 18, 20**
Spontaneous movement 9
Spores 26
Sprengelia 178
Stamens 118
Starch 73, 91, 92 95
  in leaves **96, 97**
  making **96**, 97, **98**, 99
  test 92, 95, **96, 97**, 99
Stalactites 11
Stalagmites 11
Stick insect 51
Stigma 118, 127
Stinging caterpillar **35**, 36
Structure of flower 116-118
Stylidium **180**
Successful animals **31**
    plants **31**
Sugar 73, 89, **91, 92**
Sugar and starch **91, 92**, 95
Sugar cane 89, **90**
Sugar in leaves 95
Sundew 22, **23**
Swamp Epacris 178
Swimming plants **17**
Sydney Red Gum **183**

T

Tadpoles 32, **33**, 34 50 53, **136**
  breathing pore 138
  emergence 32, 138
  feeding 138
  mouth 138
  respiration 138
  tail 139
Tambourine Mountain **164**
Tasmanian Devil **188**
Tasmanian Wolf 188
Teatree **130**
Teatree in swamps 172
Telopea 176
Test for carbon dioxide 75 102
Test for starch 92 96
Thistle fruit 120, 133
Thorn Apple **130**
Thorn Bush **60**, 63, **64, 66**
Tiger moth caterpillar **35**, 50
Toads **33**, 34, 50, 53, **136**, 139
  and reproduction **10**
Toads' eggs **32, 33**, 34, 50, 53, **136, 144**
  life history **10, 33, 136**, 139
  reproduction 110
Toadstools **24**, 25, **26, 27**
Tomato moth 152
Tomatoes **90**, 91
Tortoise Murray River **54**
Tree Ferns **168**
Trigger Plant **180**
True leaves **59**

INDEX

[Pages with Illustrations shown in bold figures]

Tumblers, mosquito **82**, 83, 109, 154, 155
Turtle, Murray River **54**

V

Variegated leaves **97**, 98

Vegetation, Australian 162 et seq
    brush 162, 163, **164**, **166**, **168**
    desert 162
    eucalypt forest 165, **171**
    Gippsland brush 165, **166**
    hardwood forest 165
    jungle 162, **164**
    open forest 165, **169**
    semi-desert 162, **177**
Vine moth 151

W

Wagtail 12, **43**, 51, 53
Wallabies 135, 188
Wanderer butterfly 140-148, **142**, **143**, 148, 153
    caterpillars **39**, 50, 140, 141, **143**, **145**
    pupa **39**, 50, 140, 142, **145**, **146**
Warning cry of birds 42
Waratah 176
Water beetle 35, 50, 53 161
    boatmen 34, 50, 53
    bugs 34
    mole 188
    plants 99
    tiger 32
Wattle goat moth 152
Wattle fruit **130**, 131
Wattle phyllodes **59**, 60, **64**, **66**
Wattles 60, **64**, **66**, 130, 131, 167
Wax flower 175
Wild flower protection 171
Wind scattering 183
Web of redback spider **42**
Weeds 31
Wheat **90**, **91**
Woody Pear **130**, 131, 182
Woolly bear **36**, 50, 53
Woolly caterpillar **36**, 50
World of Life in a Pool 32
Wrigglers, mosquito **82**, 83, 108, 154, **155**

X

Xylomelum **130**, 182

Y

Yellow fever 155-156
Young of animals 131
    of birds 135
    of caterpillars 134
    of cats 134
    of cows 134
    of fish 134
    of frogs 134, 135
    of horses 134
    of humans 134
    of insects 135
    of lizards 135
    plant 113, 116
    of rabbits 134
    root 113
    shoot 113
    of snakes 134, 135
    of toads 135

COLOURED PLATES

Open Forest Country at Mt Zero, Victoria Frontispiece
Do you know all the things a living plant can do? Facing page 16
The World of Life in a Pool ,, ,, 32
Food for a day ,, ,, 96
Plants produce new plants like themselves ,, ,, 112
Many different kinds of animals lay eggs ,, ,, 144
A Study of the Silver Wattle ,, ,, 160
A Field of Daisies ,, ,, 176
Open Forest Country near Bendigo ,, ,, 192